STATE OF MONTANA
NATURAL RESOURCE DAMAGE PROGRAM

APPENDICES A - E
TERRESTRIAL RESOURCES INJURY ASSESSMENT REPORT
UPPER CLARK FORK RIVER NPL SITES

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APPENDIX A

Assessment of Injury to Soils: Concentrations of Hazardous Substances in Exposed Soils and Comparison with Baseline Conditions

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1.0 INTRODUCTION

The assessment of injury to terrestrial resources in the upper Clark Fork Basin focused on soils, vegetation, wildlife, and wildlife habitat; these three components of the terrestrial ecosystem were treated collectively because of the ecological relationships between them. The assessment focused on two principal areas:

- Upland areas to the north, west, and south of the Anaconda smelter stack that have been exposed to hazardous substances released as primary smelter emissions or secondary fugitive emissions

- Riparian zones, including soils, floodplain sediments, and vegetation, of Silver Bow Creek and the upper Clark Fork River that have been exposed to hazardous substances via deposition of river-transported tailings and mixed tailings/alluvium.

The study was designed to establish linkages between 1) elevated concentrations of hazardous substances in soils, 2) observed injury to vegetation, 3) laboratory-determined phytotoxic responses, and 4) suitability of injured areas to support viable populations of wildlife.

Because of the dependent ecological relationships between soil, vegetation, and wildlife, the assessment of injury to terrestrial resources was designed so that information pertinent to each was collected at common sampling sites within each designated potential impact area. The following data were collected at both impact and control sites: surface soil samples (0-2 inches and 0-6 inches); vegetation field measurements including species abundance, % cover, diversity, and cover type; and habitat data for wildlife habitat evaluation models. In addition, phytotoxicity tests were conducted using field-collected soils to demonstrate and quantify adverse effects of hazardous substances on plants. This appendix describes the soil sampling and analysis components of the terrestrial injury assessment.

1.1 OBJECTIVES

The overall objective of the soils investigation in upland and riparian areas in the Clark Fork Basin was to measure concentrations of hazardous substances in the surface soils of areas that appear to be grossly impacted (based on preliminary field reconnaissance), and to compare these concentrations to baseline conditions expected in the absence of hazardous substance releases from mining and mineral processing. Specific objectives of the soil sampling plan included:

- Determining baseline concentrations of hazardous substances in soils using control sites comparable to those sampled in impact areas.

- Determining soil concentrations of hazardous substances in impacted upland and riparian areas.

- Comparing concentrations of hazardous substances in the impact area soils to concentrations in control area soils. This comparison tested the null hypothesis that concentrations of hazardous substances were similar in impact and control sites.

2.0 METHODS

2.1 FIELD STUDY DESIGN - OVERVIEW

2.1.1 Identification of Impact Areas

The assessment of injury to terrestrial resources was limited to areas where apparent gross injury to soils, vegetation, and/or wildlife habitat was observed. Impacted areas were preliminarily delineated using a combination of remote sensing (aerial photographs) and field observations. Grossly injured areas were defined as having:

- Complete or virtual elimination of the indigenous major plant associations
- Little or no regeneration of the indigenous major plant associations
- Extensive topsoil exposure and erosion associated with vegetation loss.

Delineation of impact areas in the riparian and upland areas was conducted independently, using identical criteria. Areas delineated as potentially "impacted" were those that were hypothesized as having been injured as a result of hazardous substance releases. In the remainder of this appendix, they are referred to as the "impact" areas.

2.1.2 Control Area Selection

Control sites were employed in the study to determine baseline concentrations of hazardous substances. Control area selection was based on criteria specific to Natural Resource Damage Injury Assessment:

- One or more control areas shall be selected based on their similarity to the assessment area and lack of exposure to the discharge or release [43 CFR § 11.72 (d)(1)].

- The control area shall be comparable to the habitat or ecosystem at the assessment area in terms of distribution, type, plant species composition, plant cover, vegetative types, quantity, and relationship to other habitats [43 CFR § 11.72 (k)(3)(A)].

- Physical characteristics of the control and assessment areas shall be similar [43 CFR § 11.72 (k)(3)(B)].

- If more than one habitat or ecosystem type is to be assessed, comparable control areas should be established for each, or a control area should be selected containing those habitat types in a comparable distribution [43 CFR § 11.72 (k)(3)(C)].

- Where the discharge or release occurs in a medium flowing in a single direction, such as a river or a stream, at least one control area upstream or up current of the assessment area shall be included, unless local conditions indicate such an area is inapplicable as a control area [43 CFR § 11.72 (d)(1)].

To facilitate selection of appropriate control sites, the impact areas were classified according to distinct geologic, topographic, and ecological factors that are known to determine or correlate well with the distribution of vegetation and potential vegetation communities. Using the classification criteria, upland sites and riparian reaches were identified to be used as control comparisons.

Criteria used to characterize upland samples sites included solid geology, elevation, slope and drainage aspect, slope steepness, and distance from roads. Upland control site selection was guided by the criteria listed above; final decisions were aided by groundtruthing, professional judgement, and local botanical and ecological expertise.

Riparian reaches were classified by valley bottom type, width, gradient, sinuosity, and stream morphology. Since there is no comparable reach upstream of the injury, and there presently exists little or no vegetation nor are there historical data describing the original vegetation at the assessment site, control areas were selected based on their physical similarity to the assessment area and lack of exposure to mining-related impacts. Climate, as determined by elevation and valley orientation, was included in the selection because of its integrated effect on adjacent wildlife habitat. Control reach selection was guided by the criteria listed above; final decisions were aided by groundtruthing, professional judgment, and local riparian vegetation expertise.

2.2 UPLAND

2.2.1 Delineation of Upland Impact Areas

Three distinct upland impact areas were delineated as described above, and area boundaries were transferred to USGS 7.5' quadrangles: Area A: Stucky Ridge, including hills north of Stucky Ridge [3.8 square mi (9.8 square km)]; Area B: Smelter Hill Area, including the A and C hills, Weather Hill, and slopes to the south and west of the stack [7.3 square mi (18.9 square km)]; and Area C: Mount Haggin uplands and Mill Creek, extending to the Continental Divide [6.7 square mi (17.3 square km)] (Figure 2-1). These areas represent 17.8 square mi (46.1 square km) of uplands.

North-south transects were established at 1-km intervals within each of the upland impact areas delineated. The transects conformed with north-south Universal Transverse Mercator (UTM) lines (compass bearing 345°). UTM north-south and east-west intersections were sample site loci for the 40 soil sampling transects; these loci are labeled in Figure 2-1.

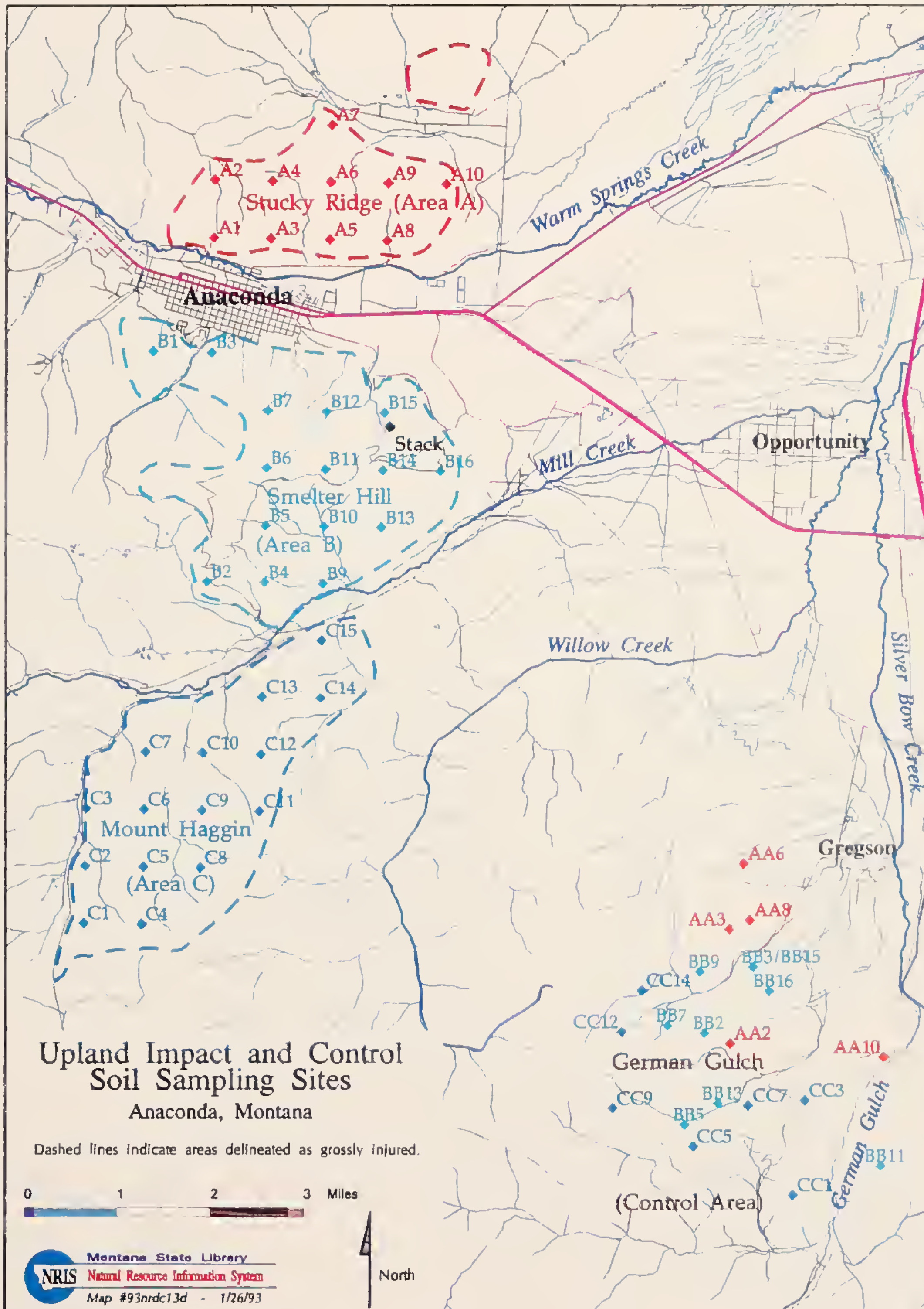

Figure 2-1. Upland Impact and Control Soil Sampling Sites.

2.2.2 Upland Control Areas

The German Gulch area (Opportunity and Burnt Mountain USGS 7.5' quadrangles) was chosen based on its proximity to the impact areas [approximately 8 mi south (12.9 km)], and its similarity in orientation and elevation to the upland impact areas.

For approximately every second impact site, three potential control sites were located within the German Gulch area using criteria described in Section 2.1.2. From those three, one was randomly selected as the control site. Twenty control sites (5 for Stucky Ridge, 8 for Smelter Hill, and 7 for Mount Haggin) were established in the German Gulch area (Figure 2-1). Table 2-1 and Figure 2-1 list impact and corresponding control sites.

Table 2-1
Sample Site Designations for Upland Impact Sites and Paired Control Sites

Stucky Ridge		Control Sites		Smelter Hill		Control Sites		Mount Haggin		Control Sites	
Label	Type	Label	Type	Label	Type	Label	Type	Label	Type	Label	Type
A-1	Chemistry			B-1	Chemistry			C-1	Extended	CC-1	Chemistry
A-2	Screening	AA-2	Chemistry	B-2	Screening	BB-2	Screening	C-2	Chemistry		
A-3	Extended	AA-3	Screening	B-3	Extended	BB-3,15	Extended	C-3	Screening	CC-3	Extended
A-4	Chemistry			B-4	Screening			C-4	Chemistry		
A-5	Chemistry			B-5	Extended	BB-5	Chemistry	C-5	Screening	CC-5	Extended
A-6	Extended	AA-6	Chemistry	B-6	Chemistry			C-6	Chemistry		
A-7	Chemistry			B-7	Chemistry	BB-7	Chemistry	C-7	Extended	CC-7	Chemistry
A-8	Extended	AA-8	Chemistry	B-8	Chemistry			C-8	Chemistry		
A-9	Chemistry			B-9	Screening	BB-9	Screening	C-9	Extended	CC-9	Chemistry
A-10	Extended	AA-10	Chemistry	B-10	Chemistry			C-10	Chemistry		
				B-11	Extended	BB-11	Chemistry	C-11	Chemistry		
				B-12	Chemistry			C-12	Screening	CC-12	Chemistry
				B-13	Extended	BB-13	Extended	C-13	Chemistry		
				B-14	Chemistry			C-14	Extended	CC-14	Screening
				B-16	Extended	BB-16	Chemistry	C-15	Chemistry		

Sample type is explained in Section 2.4.1 and in the SOPs (Attachment A).

Thus, in the Stucky Ridge area, 10 UTM grid intersections were established as soil sample sites; control sites were located for every second intersection (5 sites). In the Smelter Hill area, 16 UTM grid intersections were established as sampling sites; one of those was not sampled (B15) because it fell in close proximity to the smelter stack, where soils have been adequately sampled as part of RI/FS activities. For 8 of the 16 sites, a paired control site was selected. In the Mount Haggin area, 15 UTM grid intersections were established as soil sampling sites; for 8 of those, a paired control site was selected.

2.2.3 Sampling Design

Each soil sample collected from the impact and control sites was composited from five sub-samples. Sub-samples were collected along 500-meter north-south transects at approximately 100-meter intervals. In the impact areas, transects were centered on the UTM intersections; control site transects were centered on the point selected as the control. Ten composite soil samples were collected from Stucky Ridge, 15 from Smelter Hill, and 15 from Mount Haggin. Five paired control samples were collected for comparison to Stucky Ridge soils, eight for comparison to Smelter Hill soils, and seven for comparison to Mount Haggin soils (Figure 2-1).

Control and impact sample transects on Stucky Ridge, Smelter Hill, and Mount Haggin, and German Gulch control sites were marked on USGS 7.5' quadrangles (Anaconda North and South, Opportunity, and Burnt Mountain), and latitude/longitude coordinates for each sample were determined. In the field, each sub-sample point was located using the 1:24,000 maps. Before sampling, each sub-sample point was flagged and identified by a unique number and letter sequence.

2.3 RIPARIAN AREAS

2.3.1 Delineation of Impact Reaches

Three impacted riparian areas in the Clark Fork Basin were identified: Silver Bow Creek from downstream of the Colorado Tailings to the Warm Springs Ponds, the upper Clark Fork River from the Warm Springs Ponds discharge to Deer Lodge, and the Opportunity Ponds. Silver Bow Creek and the upper Clark Fork River had been previously subdivided into four reaches during the course of work to determine injury to fish habitat and populations (Lipton, et al., 1995). The four reaches, defined by geomorphology and hydrology, were used as the basis for sampling the riparian soils, vegetation, and wildlife habitat. The four reaches, hereafter referred to as the impact reaches, were:

- Silver Bow Creek from downstream of the Colorado Tailings in Butte to the upstream end of the Durant Canyon (upper Silver Bow Creek)

- Silver Bow Creek from the upstream end of the Durant Canyon to the downstream end (lower Silver Bow Creek)

- Silver Bow Creek from where it emerges from the Durant Canyon to its discharge into the Warm Springs Ponds

- The Clark Fork River from the Warm Springs Ponds discharge to Deer Lodge.

Figure 2-2 shows the location of the sample transects.

Reaches 1, 3, and 4 were sampled to determine and quantify injury to riparian vegetation. Reach 2 was not sampled.[1] The Opportunity Tailings Ponds were also sampled as a fifth distinct riparian impact area; current drainage patterns suggest that the approximately 3,400 acres now covered by the Opportunity Ponds supported wetland communities associated with Warm Springs Creek, Mill Creek, Willow Creek, and additional minor drainages. Criteria used to classify the impact reaches identified above and to select control reaches were based on vegetation characteristics and the factors that control the composition of potential riparian vegetation and adjacent upland vegetation. The factors include valley bottom type, gradient, sinuosity, elevation, and stream basin orientation (see Appendix C).

2.3.2 Selection of Control Reaches

Montana stream data previously reviewed for the fisheries injury assessment were used to select suitable control reaches based on the criteria described above. Three stream reaches were identified as potential control sites for each of the three impact reaches; the nine reaches initially considered were among those identified as potential control reaches for the fisheries assessment. Each was groundtruthed to ensure comparability. Divide Creek from the confluence of the North and East Forks was selected as the control for upper Silver Bow Creek. The Little Blackfoot River from Elliston to Avon was selected as the control reach for lower Silver Bow Creek, and Flint Creek from Sheryl to the Clark Fork confluence was selected as the control for the upper Clark Fork River.

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[1] Reach 2 was not sampled because of time constraints. The sources of hazardous substances and pathways of transport through Reach 2 are identical to the sources and pathways identified for Reaches 1 and 3. Stream velocity through the canyon is greater, and one would expect reduced fluvial deposition; however, the estimated volume of tailings between Miles Crossing and Finlen (Reach 2) is 1.14 to 1.6 million cubic yards (Canonie, 1992). In addition, the railroad bed, constructed of mine-waste material, closely parallels the creek through the canyon. The results of the analysis described in this appendix support the hypothesis that slickens composition is sufficiently uniform to consider the sampled population as representative of slickens composition in general; see Section 3.2.3.

2.3.3 Sampling Design

Riparian soils within each of the Silver Bow Creek assessment units were classified as one of two types, slickens or nonslickens, based on observed soil (or substrate) and vegetation characteristics using maps, aerial photographs, previous studies, and field visits. Areas classified as slickens were those where tailings or mixed alluvium and tailings have been deposited, and vegetation is completely or virtually absent. Developed areas devoid of vegetation (roads, parking lots, railroads, other structures) were classified as nonslickens.

Soil sampling transects were located randomly within each reach, but were confined to floodplain areas defined as slickens. To select locations for soil transects, the length of each reach was measured. Each side of the river was treated separately. A random number generator was used to select six random numbers. Random numbers corresponded to linear distance downstream on the west (or south) side of the river, continuing upstream on the east (or north) side of the river. If a transect at a selected point did not cross an area delineated as a slickens, a new random number was generated.

Soil transects were oriented perpendicular to the river. Five sub-samples were composited along each slickens transect. Soil sub-samples were equally spaced at such a distance to obtain the maximum number of sub-samples, up to five, at least 2 meters apart. A random number was generated to determine the distance in meters (0-9 meters) from the edge of the stream for placement of the first sub-sample point. If a slickens area was discontinuous laterally (i.e., a vegetated area existed within the slickens), the slickens was treated as continuous, and the intervening nonslickens area was not sampled.

In the Opportunity Ponds area, five 1,000 meter UTM intersections were sampled as described for soil sampling in the upland areas. A 500-meter north-south transect centered on a UTM intersection was sampled at approximately 100 meter intervals. Sub-samples were composited to produce five composited samples. Sampling points were located and flagged before soil sampling.

Six transects were established in each control reach following the same methods used to position transects in the impact reaches. Transects were oriented perpendicular to the river, and sample sites were established as described above, using a random number to establish the location of the riverside sample point. Transect length was determined as the mean length of transect width in the corresponding paired impact reach.

A distinct control site was not established for the Opportunity Ponds. Rather, the Opportunity Ponds were compared to the mean of the 18 sites sampled as controls for the other riparian impact reaches. Sample transect location, transect length and sample type are identified in Table 2-2.

Figure 2-2. Location of Riparian Sampling Transects: Silver Bow Creek and the Clark Fork River.

Table 2-2
Locations and Descriptions of Control and Impact Transects

Reach Name	Label	Control/ Impact	Longitude	Latitude	Sample Type
Silver Bow Creek #1	R1	Impact	112°36'57"	46°00'10"	Chemistry
Silver Bow Creek #2	R2		112°34'56"	46°00'01"	Chemistry
Silver Bow Creek #3	R3		112°40'46"	46°00'03"	Chemistry
Silver Bow Creek #4	R4		112°40'20"	46°00'21"	Extended
Silver Bow Creek #5	R5		112°43'33"	46°00'43"	Chemistry
Silver Bow Creek #6	R6		112°42'50"	46°00'20"	Chemistry
Divide Creek #1	RR1	Control	112°44'12"	45°46'38"	Chemistry
Divide Creek #2	RR2		112°43'38"	45°47'08"	Chemistry
Divide Creek #3	RR3		112°43'18"	45°47'58"	Chemistry
Divide Creek #4	RR4		112°42'16"	45°49'50"	Chemistry
Divide Creek #5	RR5		112°42'16"	45°50'00"	Chemistry
Divide Creek #6	RR6		112°41'54"	45°50'30"	Chemistry
Silver Bow Creek #7	R7	Impact	112°47'42"	46°02'39"	Chemistry
Silver Bow Creek #8	R8		112°47'39"	46°02'35"	Extended
Silver Bow Creek #9	R9		112°48'00"	46°05'10"	Chemistry
Silver Bow Creek #10	R10		112°48'01"	46°03'56"	Chemistry
Silver Bow Creek #11	R11		112°48'00"	46°06'43"	Chemistry
Silver Bow Creek #12	R12		112°48'03"	46°05'51"	Chemistry
Little Blackfoot River #1	RR7	Control	112°28'11"	46°34'20"	Extended
Little Blackfoot River #2	RR8		112°27'21"	46°34'11"	Chemistry
Little Blackfoot River #3	RR9		112°33'04"	46°35'30"	Chemistry
Little Blackfoot River #4	RR10		112°30'28"	46°34'28"	Chemistry
Little Blackfoot River #5	RR11		112°34'16"	46°36'00"	Chemistry
Little Blackfoot River #6	RR12		112°33'58"	46°36'00"	Chemistry
Clark Fork River #1	R13	Impact	112°45'37"	46°13'20"	Extended
Clark Fork River #2	R14		112°44'38"	46°16'09"	Extended
Clark Fork River #3	R15		112°44'20"	46°16'36"	Chemistry
Clark Fork River #4	R16		112°44'16"	46°18'19"	Chemistry
Clark Fork River #6	R18		112°44'12"	46°22'41"	Chemistry
Flint Creek #1	RR13	Control	113°11'11"	46°34'51"	Extended
Flint Creek #2	RR14		113°12'23"	46°34'08"	Chemistry
Flint Creek #3	RR15		113°10'52"	46°35'29"	Chemistry
Flint Creek #4	RR16		113°09'32"	46°36'51"	Chemistry
Flint Creek #5	RR17		113°09'11"	46°37'03"	Chemistry
Flint Creek #6	RR18		113°06'02"	46°37'51"	Chemistry
Opportunity Ponds #1	OP1	Impact	112°51'06"	46°07'49"	Chemistry
Opportunity Ponds #2	OP2		112°50'16"	46°08'21"	Chemistry
Opportunity Ponds #3	OP3		112°49'39"	46°08'54"	Chemistry
Opportunity Ponds #4	OP4		112°49'39"	46°07'49"	Chemistry
Opportunity Ponds #5	OP5		112°48'46"	46°08'21"	Chemistry

2.4 SOIL SAMPLING PROTOCOLS

2.4.1 Sample Description

Three types of soil samples were collected:

- Soil samples for chemical analysis only (designated as "chemistry" samples) were collected from the 0-2 inch soil depth at all upland and riparian impact and control sites. The amount of soil collected at chemistry sample sites [see standard operating procedures (SOPs), Attachment A] was sufficient to provide material for soils metals analysis, archives, and splits for ARCO. Sixty-five chemistry-only samples were collected.

- Soil samples for phytotoxicity screening tests were collected from the 0-2 inch depth at all sites designated for vegetation and wildlife evaluation. Screening sample volume was sufficient for soil chemical analyses and screening phytotoxicity tests. Fourteen screening samples were collected. The two screening samples collected from riparian control reaches were inadvertently combined by the laboratory during the mixing process. Thus, the combined sample (RR-7 and RR-13) provided an average control soil for riparian screening-level phytotoxicity tests.

- Extended samples supplied soils for chemical analysis, screening level phytotoxicity tests, and extended phytotoxicity tests. Extended samples were collected at sites designated as both habitat evaluation and phytotoxicity sites in each impact and control area (see Appendix C). Samples were collected from the 0-2 inch soil depth as described for screening samples, and from the 0-6 inch depth. The total amount collected from the 0-2 inch depth was the same as that collected for screening samples (sufficient to provide material for chemical analysis and screening phytotoxicity tests). The total amount collected from the 0-6 inch depth was sufficient to provide for chemical analysis and extended phytotoxicity tests. Twenty-two extended samples were collected and analyzed.

2.4.2 Sample Collection

For a detailed account of the soil sampling protocols see the SOPs (Attachment A). Either a carbon steel shovel or a dedicated scoop, as necessary, was used to dig each sub-sample pit. Shovels were decontaminated before sampling at each new transect. One side of the sub-sample pit was cut as a vertical face; a clean scoop, one per transect and sample type, was used to scrape soil material from the exposed wall to the necessary depth. Sample bags were filled, sealed, and labeled according to the transect number, sub-sample number, and sample

depth. Pertinent information as per the SOPs was noted in the field notebook. All samples were preserved at 4°C for transport to the laboratory. Chain of custody forms were completed for all samples. Field QA/QC was performed according to the Quality Assurance Project Plan in the Assessment Plan.

2.4.3 Changes to the Project Sampling Plan

2.4.3.1 Upland Sampling

This section describes changes to the project sampling plan in response to actual conditions encountered in the field. Rationale for these changes are also presented.

- It was indicated in the Assessment Plan that a Global Positioning System (GPS) would be used to locate the upland transects and sample points. The GPS was unable to locate the necessary number of satellites, presumably because of the rugged terrain and signal interference, to establish a point with acceptable precision. For that reason, sites were located using USGS maps, compasses, and landscape features.

- Several candidate transects and sub-sampling sites included in the sampling plan were not sampled due to site access constraints. The southernmost sub-sample points of transects A1 and A3 landed within Old Works property, and thus were not sampled. The southernmost point on transect B9 was not sampled because it was underwater. Transect B8 was not sampled because of access constraints.

- The following sampling protocol deviations were made in response to field conditions:

    (a) Two sub-samples, one from each of A3 and A5, were discarded because they were located in waste piles (railroad bed) and were considered un-representative.

    (b) Transect BB2 was initially sampled in a rainstorm; samples were discarded and the transect was entirely re-sampled in fair weather, at re-located sub-sampling sites.

    (c) Sites C3, C5, and C12 were initially sampled as chemistry sites instead of screening sites. These sites were re-visited and sampled as screening samples at re-located sub-sampling sites.

Control sites were chosen based on the physical features described in Section 3.1.2 of this report. One control site was selected as a control for two impact sites with similar characteristics (BB3,15). Site B15 was not sampled for soils because of its proximity to the stack. Therefore, in all statistical calculations, control sample BB3,15 was used as a paired control for site B3 only.

2.4.3.2 Riparian Sampling

Several riparian control transects were truncated because of access constraints or to ensure that samples were collected within the riparian zone. On Divide Creek, two of the six transects were truncated because of flooding in adjacent hayfields and access difficulties (RR2, RR6). One of these was initially located entirely within a flooded hayfield, and was re-located 100 meters downstream to a 30 meter unflooded area (RR6). Two transects on Divide Creek were shortened because they intersected with railroad tracks (RR3, RR5). Two transects on the Little Blackfoot were shortened because they intersected with uncut hayfields and because of access difficulties (RR11, RR12). One transect on Flint Creek intersected a road and was shortened to fit within the riparian zone (RR13). One transect on Flint Creek was shortened by 5 meters because of an error in calculation (RR14). Re-establishment and sampling of all modified transects followed specified sampling protocols.

Transect R17, on the Clark Fork River, was not sampled. A second transect site was randomly selected according to the protocol for site selection; however, the second site selected was inaccessible. Because of time constraints, the site was not sampled.

2.4.3.3 Field Quality Assurance/Quality Control

Triplicate field QA/QC samples were collected at four transects. This is equivalent to a rate of one transect per 25 instead of the one per 20 specified in the sampling plan.

2.5 LABORATORY ANALYSES

Soil sub-samples were composited, dried, and split for analyses. Splits of all 2-inch and 6-inch samples of all types (chemistry, screening, and extended samples) were analyzed for total metals. The 2-inch extended samples were also analyzed for plant-available metals. Splits of samples used in phytotoxicity testing (2-inch screening and extended samples) were analyzed for the following: pH, texture (% sand, % silt, and % clay), concentrations of nitrate-nitrogen, potassium, and phosphorous, percentage organic matter (%OM), and cation exchange capacity (CEC). Splits of all samples were made available to ARCO; archived splits are maintained at NRDLP in Helena.

Soil samples were sent to Montana State University (MSU) Soil Analytical Laboratory for the determination of general soil parameters and soil nutrients; splits were sent to the Montana Bureau of Mines and Geology (MBMG) Analytical Division for the determination of metal concentrations. The analyses performed and the methodologies used at each institution are referenced below.

2.5.1 Montana State University Soil Analytical Laboratory Analyses

Samples sent to MSU were analyzed to determine general soil parameters and soil nutrient status. Soil parameters quantified included soil organic matter, pH, cation exchange capacity, and particle size analysis. The methodologies for determining each of these parameters are described in the references identified in Table 2-3.

The soil nutrient analysis included nitrate ($Ca(OH)_2$ extractable), phosphorous ($NAHCO_3$ extractable), and potassium (NH_4OAc extractable). The methodologies for determining these parameters can be found in the references identified in Table 2-4.

2.5.2 Montana Bureau of Mines and Geology Analytical Division Analyses

Soil samples (including QA blanks, wipes) sent to MBMG were analyzed for the total concentration of five metals: arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn). In addition, a subset of the soils (including QA blanks, wipes) were extracted with DTPA (diethylenetriaminepentaacetic acid) to assess the availability of the metals to plants.

The methodology for determining total metal concentrations was a combination of Environmental Monitoring Systems Laboratory Method 200.8 (Long and Martin, 1991) and the U.S. EPA proposed Method 6020 CLP-M Version 8.0.

The methodologies used in determining plant available metal concentration were identical to those used in the analysis of total metal, except the extraction followed the procedure detailed in Appendix H of the Anaconda Smelter RI/FS LAP (Revision 3 January, 1991).

2.6 STATISTICAL METHODS

Metals and arsenic concentration data were summarized by arithmetic average, maximum, minimum, and standard deviation. Summary statistics were calculated for Stucky Ridge, Smelter Hill, Mount Haggin and their upland controls; upper Silver Bow Creek, lower Silver Bow Creek, the upper Clark Fork River and their riparian controls; and the Opportunity Ponds. Comparisons were made between 2-inch and 6-inch soil samples to assess concentration relationships with soil depth.

Table 2-3 Methodologies Used for Analyses of General Soil Parameters	
Parameter	**Reference**
Soil organic matter	Page et al., 1982 Sims and Haby, 1970
pH	Clesceri et al., 1989 Page et al., 1982 USDA Handbook No. 60
Cation exchange capacity	Bower et al., 1952
Particle size	Bouyoucos, 1936 Day, 1965 Gee and Bauder, 1979

Table 2-4 Methodologies Used for Analyses of Soil Nutrients	
Parameter	**Reference**
Nitrate	Extraction: Page et al., 1982 Sims and Jackson, 1971 Color development: Clesceri et al., 1989 Technicon Method N. 100-70W Willis, 1980
Phosphorous	Olsen et al., 1954 Page et al., 1982 Wantanabe and Olsen, 1965
Potassium	Page et al., 1982

All paired 2-inch soil samples from the upland impact areas and German Gulch controls, and impact and control paired samples grouped by area (Stucky Ridge, Smelter Hill, and Mount Haggin), were compared. The null hypothesis of no difference in the probability distributions of values measured was tested using Fisher's permutation test (paired comparison randomization test) with complete enumeration (by area) and 5,000 randomizations (over all areas) (Manly, 1991).[2] These randomization procedures are nonparametric tests of whether differences between observed concentrations of hazardous substances in impact and paired control soils could have arisen by chance from the same distribution, and they calculate the probability of that occurrence (the "p-value").

Measured values of hazardous substances in riparian impact and control soils were compared by reach. The null hypothesis of no difference in the probability of distributions of measured values was tested by the two-sample randomization test (Manly, 1991).[3] Again, the p-value of the test is reported.

Single comparisons (pooled tests below) were tested at the α = 5% level. The Boneferroni procedure,[4] with an initial significance level of α = 10%, was used for multiple comparisons on each variable. Thus, in the upland analysis, copper concentrations were compared three times: for Stucky Ridge, Smelter Hill, and Mount Haggin. The significance level in each of the three tests is 3.3% (i.e., 10%/3 samples), instead of 10%. Likewise, in the riparian soils analysis, copper concentration is compared three times: upper Silver Bow Creek, lower Silver Bow Creek, and the upper Clark Fork River. The significance level in each of the three tests is again 3.3% (i.e., 10%/3 samples).

Patterns in the distribution of concentrations in soils with distance from the stack were analyzed using randomized linear regression (comparison of the observed value of the slope with the slope obtained by pairing the X and Y values at random). The null hypothesis for

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[2] If the paired impact and control soil concentrations are random samples from identical populations, then the differences (impact - control concentration) are equally likely to be positive or negative. Paired comparison randomization testing with complete enumeration tests all possible sign combinations of the observed differences and compares the observed test statistic to the randomized distribution. For n≥20, 5,000 randomizations, rather than complete enumeration, was used.

[3] If the two populations sampled are the same, then all possible allocations of observations to samples are equally likely. Two sample randomization randomly assigns the observed data points to 2 samples, in this case, 5,000 times. The observed test statistic is compared to the randomized distribution.

[4] The Boneferroni procedure assures that when making multiple comparisons of a set of treatment means, the overall confidence level associated with all the comparisons remains at or above the specified α level. The Boneferroni procedure specifies the level of significance of each comparison as α/c, where α is the overall level of significance desired and c is the number of pairs of means to be compared. The result is a set of confidence intervals with *at least* $100(1-\alpha)\%$ confidence (McClave and Dietrich, 1991).

the randomization test, that the relationship between distance and concentration has a slope of zero, was tested.

Concentrations of soil nutrients, %OM, pH, soil texture, and CEC in 23 impact soils and eight control soils were compared to test for differences in soil parameters other than hazardous substances that might affect plant growth. Impact and control samples were compared using two-sample randomization tests (Manly, 1991) with 5,000 randomizations. The null hypothesis, that concentrations of nutrients, pH, texture, percentage organic matter and CEC do not differ between control and impact soils, was tested.

3.0 RESULTS

3.1 UPLAND SOILS

Statistical summaries of metals and arsenic concentrations in Anaconda upland impact and control 2-inch and 6-inch soil samples are presented in Tables 3-1 and 3-2; raw data are provided in Attachment B.

Mean arsenic concentrations in impact area 0-2 inch soils ranged from 605.2 ppm in the Smelter Hill area to 295.8 ppm in the Mount Haggin area; mean arsenic concentrations for control 0-2 inch samples ranged from 99.4 ppm for Mount Haggin controls to 78.2 ppm for Stucky Ridge controls. In order of decreasing mean arsenic concentration, the impact areas and controls rank as follows:

> Smelter Hill >> Stucky Ridge ≈ Mount Haggin >> Mount Haggin Controls ≈ Smelter Hill Controls > Stucky Ridge Controls

Mean cadmium values for the impact area 0-2 inch soils ranged from 17.6 ppm in the Smelter Hill area to 3.8 ppm in the Stucky Ridge area; mean cadmium concentration in control 0-2 inch samples ranged from 3.5 ppm for Stucky Ridge controls to 2.6 ppm for Mount Haggin controls. In order of decreasing mean cadmium concentration, the impact areas and controls rank as follows:

> Smelter Hill >> Mount Haggin > Stucky Ridge ≈ Stucky Ridge Controls > Smelter Hill Controls ≈ Mount Haggin Controls

Mean impact area copper concentrations in 0-2 inch soils ranged from 1324.5 ppm for the Stucky Ridge area to 356 ppm for the Mount Haggin area; mean copper concentrations for control 0-2 inch samples ranged from 183 ppm for Stucky Ridge controls to 118.7 ppm for Mount Haggin controls. In order of decreasing mean copper concentration, the impact areas and controls rank as follows:

> Stucky Ridge > Smelter Hill >> Mount Haggin > Stucky Ridge Controls > Smelter Hill Controls > Mount Haggin Controls

Mean impact area lead concentrations ranged from 275 ppm for the Smelter Hill area to 117.0 ppm for the Stucky Ridge area. Mean lead concentrations for control area samples ranged from 89.4 ppm for Stucky Ridge controls to 56.5 ppm for Mount Haggin controls.

In order of decreasing mean lead concentration, the impact areas and controls rank as follows:

> Smelter Hill > Mount Haggin > Stucky Ridge > Stucky Ridge Controls > Smelter Hill Controls > Mount Haggin Controls

Table 3-1
Summary Statistics for Upland Impact and Control 2-Inch Soil Samples
(Total Metals in ppm)

Sample Identification	As	Cd	Cu	Pb	Zn
Stucky Ridge n = 10					
Arithmetic mean	303.5	3.8	1324.2	117.0	300.7
Maximum	624.3	7.3	2856.0	196.0	580.5
Minimum	142.7	2.3	513.4	68.7	167.4
Standard deviation	144.8	1.4	677.2	37.00	129.6
Stucky Ridge controls n = 5					
Arithmetic mean	78.2	3.5	183.2	89.4	150.9
Maximum	119.6	4.1	220.4	112.7	182.6
Minimum	47.2	2.2	135.5	60.8	121.0
Standard deviation	24.8	0.7	31.4	17.7	21.2
Smelter Hill n = 14					
Arithmetic mean	605.2	17.6	1229.5	275.6	562.3
Maximum	1846.7	51.2	2547.0	548.8	1515.0
Minimum	183.3	7.4	404.9	156.8	205.1
Standard deviation	410.4	12.2	627.8	109.00	363.2
Smelter Hill controls n = 8					
Arithmetic mean	90.9	2.9	143.4	58.4	141.0
Maximum	132.3	4.3	236.5	88.0	196.3
Minimum	47.3	1.7	96.4	41.0	80.2
Standard deviation	22.8	0.9	44.0	15.1	36.7
Mount Haggin n = 16					
Arithmetic mean	295.8	7.8	356.4	153.3	215.8
Maximum	630.0	14.2	678.7	229.2	379.3
Minimum	107.6	2.3	139.1	78.1	76.6
Standard deviation	144.6	3.7	155.6	49.6	93.7
Mount Haggin controls n = 7					
Arithmetic mean	99.4	2.6	118.7	56.5	115.8
Maximum	136.4	5.1	201.5	119.7	165.4
Minimum	53.0	1.3	58.6	31.1	78.4
Standard deviation	27.2	1.3	50.0	33.1	28.0

Table 3-2
Summary Statistics for Upland Impact and Control 6-Inch Samples

Location		As	Cd	Cu	Pb	Zn
Stucky Ridge	n = 3					
Arithmetic mean		253.1	3.1	1079.0	89.0	265.4
Maximum		385.6	4.0	1272.4	130.3	351.2
Minimum		184.9	2.2	935.1	64.7	191.4
Standard deviation		93.7	0.7	142.1	29.3	65.8
Smelter Hill	n = 5					
Arithmetic mean		401.6	13.1	670.5	275.6	443.7
Maximum		642.5	21.8	972.9	548.8	792.6
Minimum		114.0	4.0	395.4	156.8	240.5
Standard deviation		229.1	6.6	214.7	109.0	195.8
Mount Haggin	n = 4					
Arithmetic mean		194.3	5.4	251.3	153.3	179.8
Maximum		378.0	10.0	493.9	229.2	283.0
Minimum		93.5	2.8	118.4	78.1	103.3
Standard deviation		109.7	2.9	143.6	49.6	72.8
All controls	n = 4					
Arithmetic mean		60.1	1.5	82.1	56.5	93.7
Maximum		84.3	2.5	125.5	119.7	128.4
Minimum		40.7	0.7	41.6	31.1	68.8
Standard deviation		17.9	0.7	30.3	33.1	21.9

Mean impact area zinc concentrations ranged from 562.3 ppm for the Smelter Hill area to 215.8 ppm for the Mount Haggin area. Mean zinc concentrations for control area samples ranged from 150.9 ppm for Stucky Ridge controls to 115.8 ppm for Mount Haggin controls. In order of decreasing mean zinc concentration, the impact areas and controls rank as follows:

> Smelter Hill > Stucky Ridge > Mount Haggin > Stucky Ridge Controls > Smelter Hill Controls > Mount Haggin Controls

Mean concentrations in 0-6 inch samples were, in general, reduced in comparison to 0-2 inch samples (see Section 3.1.5). Impact area ranking by 0-6 inch soil concentrations is identical to the rankings listed above for 0-2 inch soil concentrations.

Four statistical analyses were performed to compare impact to control soil concentrations: (1) comparison of concentration of hazardous substances in all impact and all control samples; (2) comparison of concentrations of hazardous substances in individual impact area soils with concentrations in corresponding control samples; (3) analysis of distribution of hazardous substances in soils with depth; and (4) analysis of distribution of hazardous substances in soils with distance from the main smelter stack.

3.1.1 All Impact Area Samples Versus Control Samples

A comparison of concentrations of hazardous substances from pooled impact areas (n = 20) and between pooled control sites resulted in a p-value of 0.0002 (the probability that control and impact soil concentrations are the same) for all five hazardous substances (arsenic, cadmium, copper, lead, and zinc). The null hypothesis was rejected for all five hazardous substances, demonstrating that soils concentrations of these hazardous substances in the impact area are significantly elevated with respect to the control area.

3.1.2 Stucky Ridge Versus Control Samples

Stucky Ridge impact and respective control samples were compared using Fisher's permutation test to test the null hypothesis of no significant difference in the probability distributions of arsenic, cadmium, copper, lead, and zinc concentrations (total metals). Tests were conducted at the α = 3.3% level. Results are presented in Table 3-3.

The null hypothesis was rejected for arsenic, copper, and zinc; i.e., the Stucky Ridge soils have significantly higher concentrations of these elements than the paired control soils in German Gulch. Cadmium and lead concentrations in impact and control soils were not significantly different.

The degree of difference between hazardous substance concentrations in Stucky Ridge and control site soils is illustrated in Figure 3-1, which presents the means and standard deviations of impact and control area soils. Asterisks indicate statistically significant differences in mean concentration.

Table 3-3
Results of Fisher's Permutation Test Comparing Concentrations of Metals and Arsenic in Paired Impact and Control Soils

Test	Stucky Ridge vs. Controls n = 5 pairs	Smelter Hill vs. Controls n = 8 pairs	Mount Haggin vs. Controls n = 7 pairs
Element	**p-value**		
Arsenic	0.03*	0.00391*	0.00781*
Cadmium	0.25	0.00391*	0.01563*
Copper	0.03*	0.00391*	0.01563*
Lead	0.16	0.00391*	0.01563*
Zinc	0.03*	0.0031*	0.03906

* Indicates significantly greater concentrations in impact area soils for α = 3.3%.

3.1.3 Smelter Hill Versus Control Samples

Smelter Hill impact and paired control samples were compared using Fisher's Permutation Test. Concentrations of arsenic, cadmium, copper, lead, and zinc in impact samples were significantly greater than in control samples (Table 3-3 and Figure 3-1).

3.1.4 Mount Haggin Versus Control Samples

Mount Haggin impact and paired control samples were also tested using Fisher's Permutation Test. The results confirm that the impact soils have significantly higher arsenic, cadmium, copper, and lead concentrations than the control soils (Table 3-3 and Figure 3-1). Although the p-value for zinc, 0.03906, is slightly greater than the threshold p-value of 0.033 required by the conservative Boneferroni method, comparison would be significant at α = 5%.

3.1.5 Distribution of Hazardous Substances with Depth

Paired upland impact soils from the 0-2 inch layer and the 0-6 inch layer were compared using Fisher's Permutation Test to test the null hypothesis of no significant difference in the concentrations of arsenic, cadmium, copper, lead, and zinc (Table 3-4). These tests confirm that the impact soils have significantly higher arsenic, cadmium, copper, lead, and zinc concentrations in the upper stratum than in lower strata, indicating that the source of the

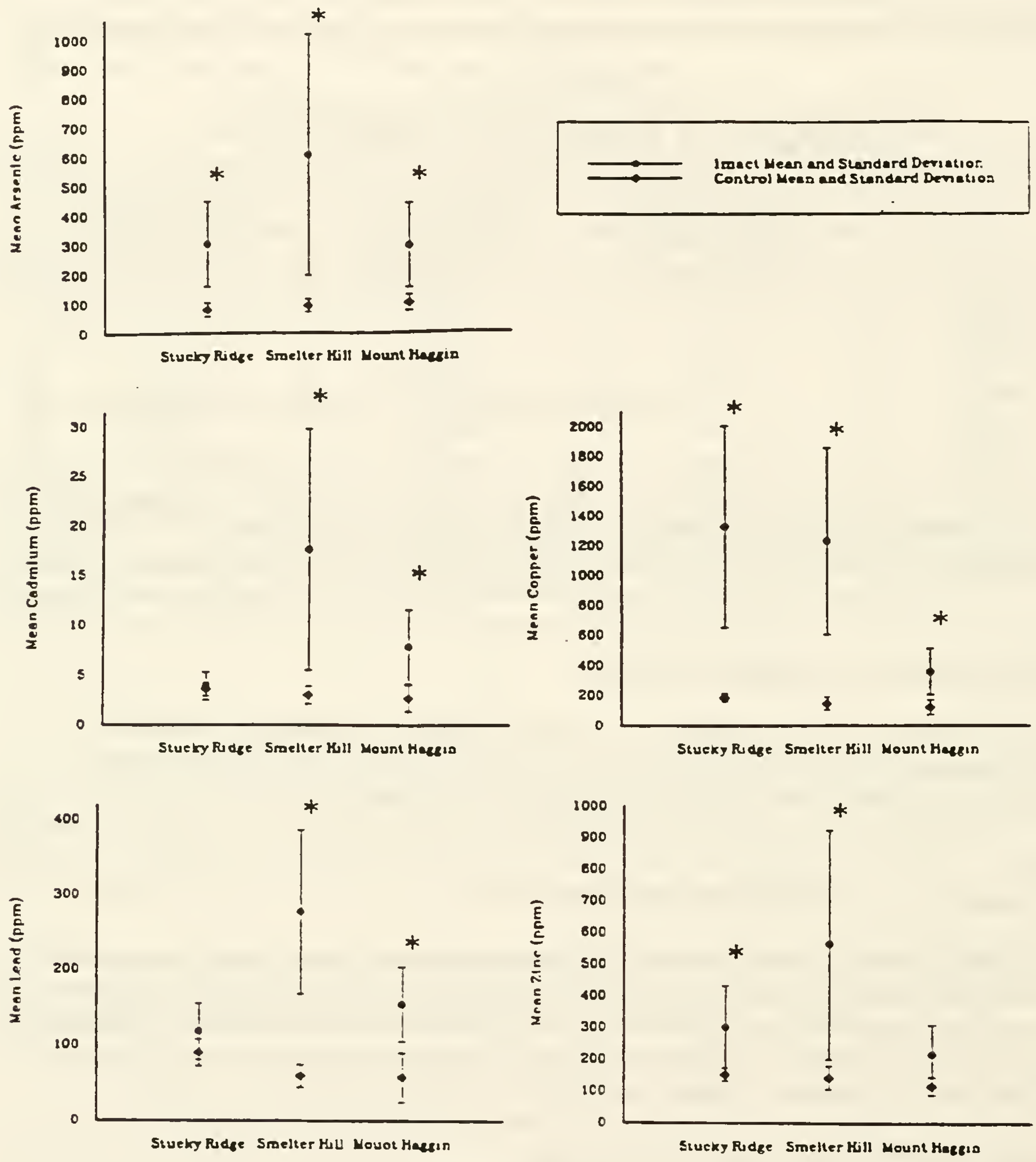

Figure 3-1. Mean Concentrations of Hazardous Substances in Impact and Control Area 0-2 Inch Soil Samples. Error bars represent the standard deviation on the mean. Stucky Ridge, Smelter Hill, and Mount Haggin areas were tested at the α = 3.3% level; * indicates means that were significantly different at α = 3.3%.

Table 3-4 Comparisons of 0-2 Inch and 0-6 Inch Soil Concentrations Using Fisher's Paired Permutation Test	
Element	**Upland Impact (n = 12 pairs) p-value (α = 5 %)**
Arsenic	0.0049*
Cadmium	0.00073*
Copper	0.00049*
Lead	0.00024*
Zinc	0.00073*
* Indicates significantly greater concentration in 0-2 inch samples for α = 5%.	

hazardous substances is surficial rather than attributable to the parent material. This result is consistent with previous studies in the Anaconda area (e.g., PTI, 1991). That even the most mobile (and typically rapidly leached from surface soil horizons) of the elements analyzed, cadmium and zinc, are elevated in surface horizons is evidence of the recent and common origin of these substances.

3.1.6 Distribution with Distance from the Main Stack

Soil concentrations of arsenic, cadmium, copper, lead, and zinc were analyzed to assess the relationship between concentration and distance from the Smelter Hill main stack. The exponential decline in concentration with distance from the stack for all five metals is illustrated in Figures 3-2 through 3-6. Randomized regression rejected the null hypothesis (slope equal to 0) for all five elements at a significance level of 1% (Table 3-5); all five exhibited a significantly negative slope.[5] Thus soils concentrations of metals and arsenic decrease with increasing distance from the stack, confirming that the stack is the principal source of hazardous substance releases.

[5] $\beta_1 < 0$ because of the inverse relationship between distance and concentrations; i.e., at greater distance from the source, concentrations decrease.

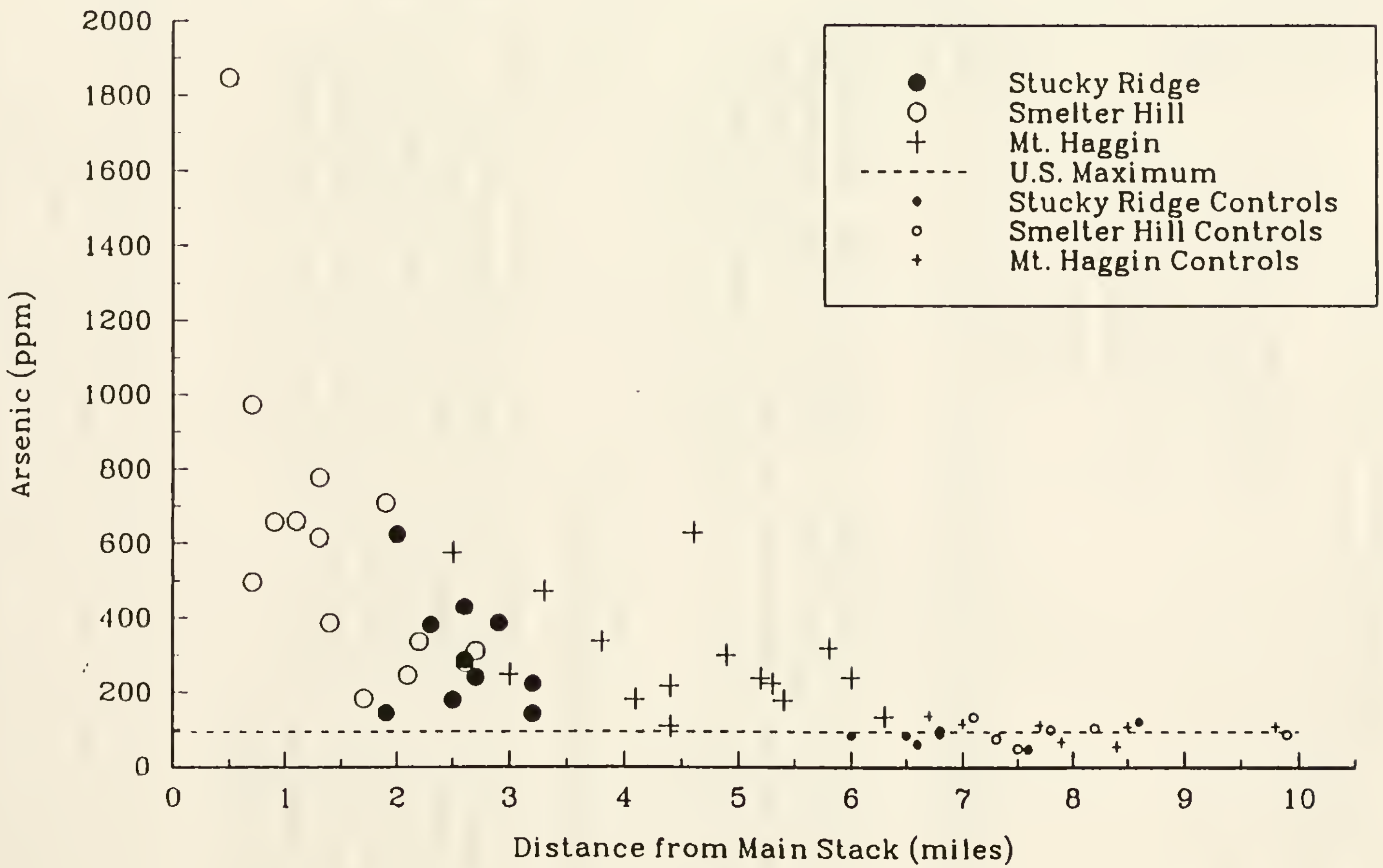

Figure 3-2. Arsenic Concentration in Soils with Distance from the Main Smelter Stack. Data points represent total arsenic (ppm) in 0-2 inch soil samples collected from the Stucky Ridge, Smelter Hill, and Mt. Haggin impact areas, and from German Gulch control sites. The dashed line indicates the upper end of the range of arsenic concentrations reported for uncontaminated soils of the United States (< 0.1 to 93.0 ppm) (Kabata-Pendias and Pendias, 1992)

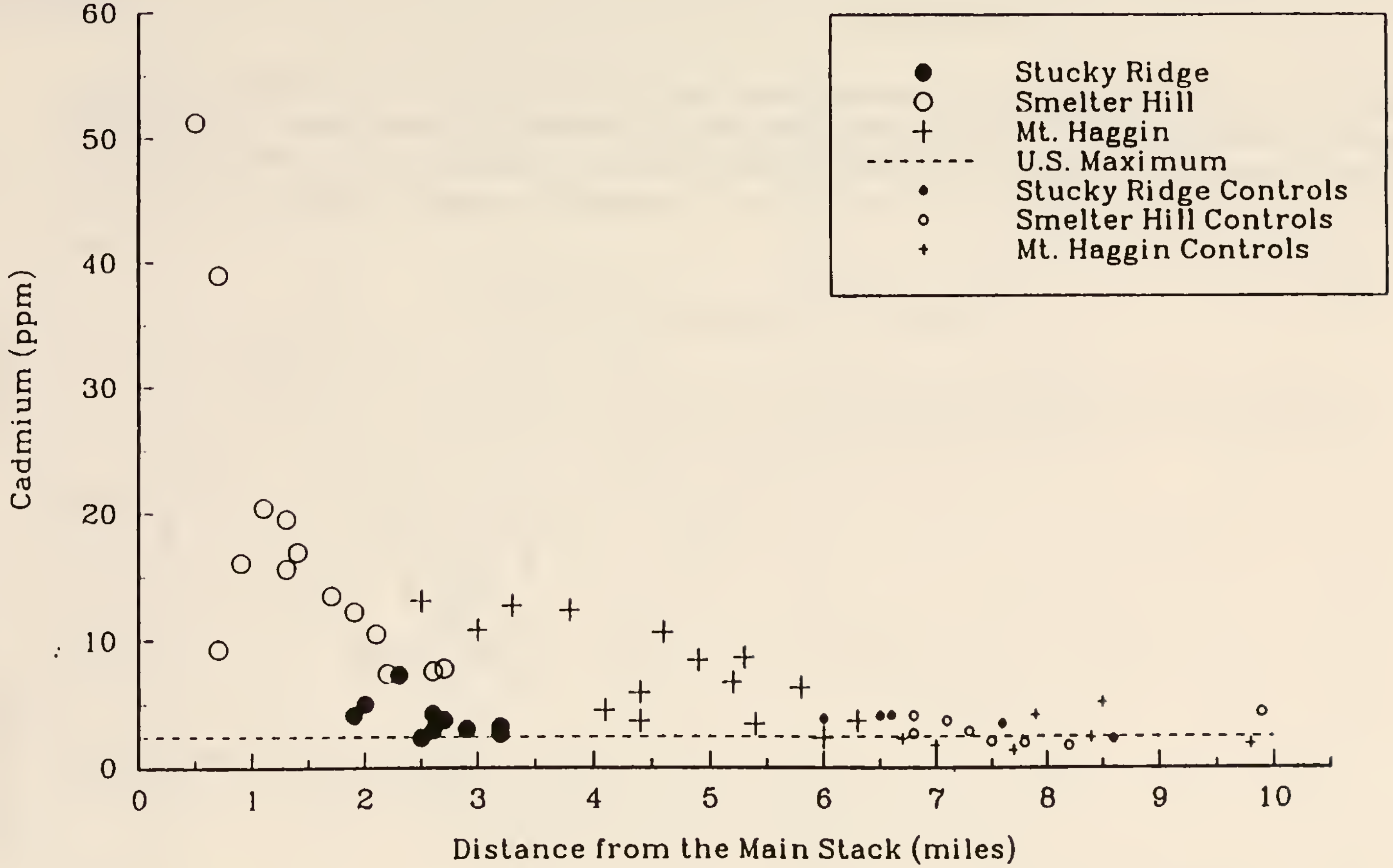

Figure 3-3. **Cadmium Concentration in Soils with Distance from the Main Smelter Stack.** Data points represent total cadmium (ppm) in 0-2 inch soils collected from the Stucky Ridge, Smelter Hill, and Mt. Haggin impact areas, and from the German Gulch control sites. The dashed line indicates the upper end of the range of cadmium reported for uncontaminated soils of the United States (0.005 - 2.4 ppm) (Alloway, 1990).

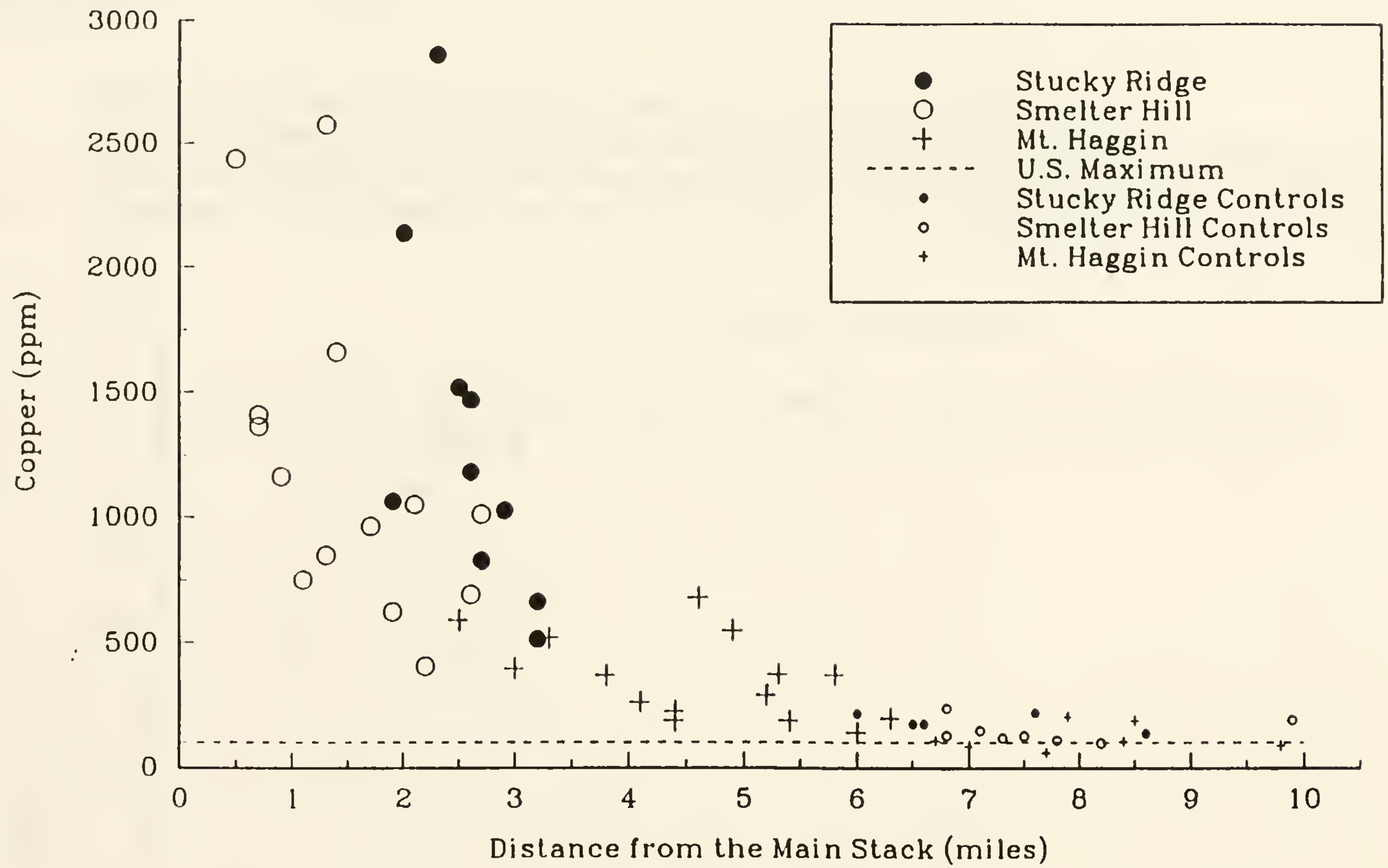

Figure 3-4. Copper Concentration in Soils with Distance from the Main Smelter Stack. Data points represent total copper (ppm) in 0-2 inch soils collected from the Stucky Ridge, Smelter Hill, and Mt. Haggin impact areas, and from the German Gulch control sites. The dashed line indicates the upper end of the range of copper concentrations typically reported for uncontaminated soils of the United States (1-100 ppm) (Kabata-Pendias and Pendias, 1992).

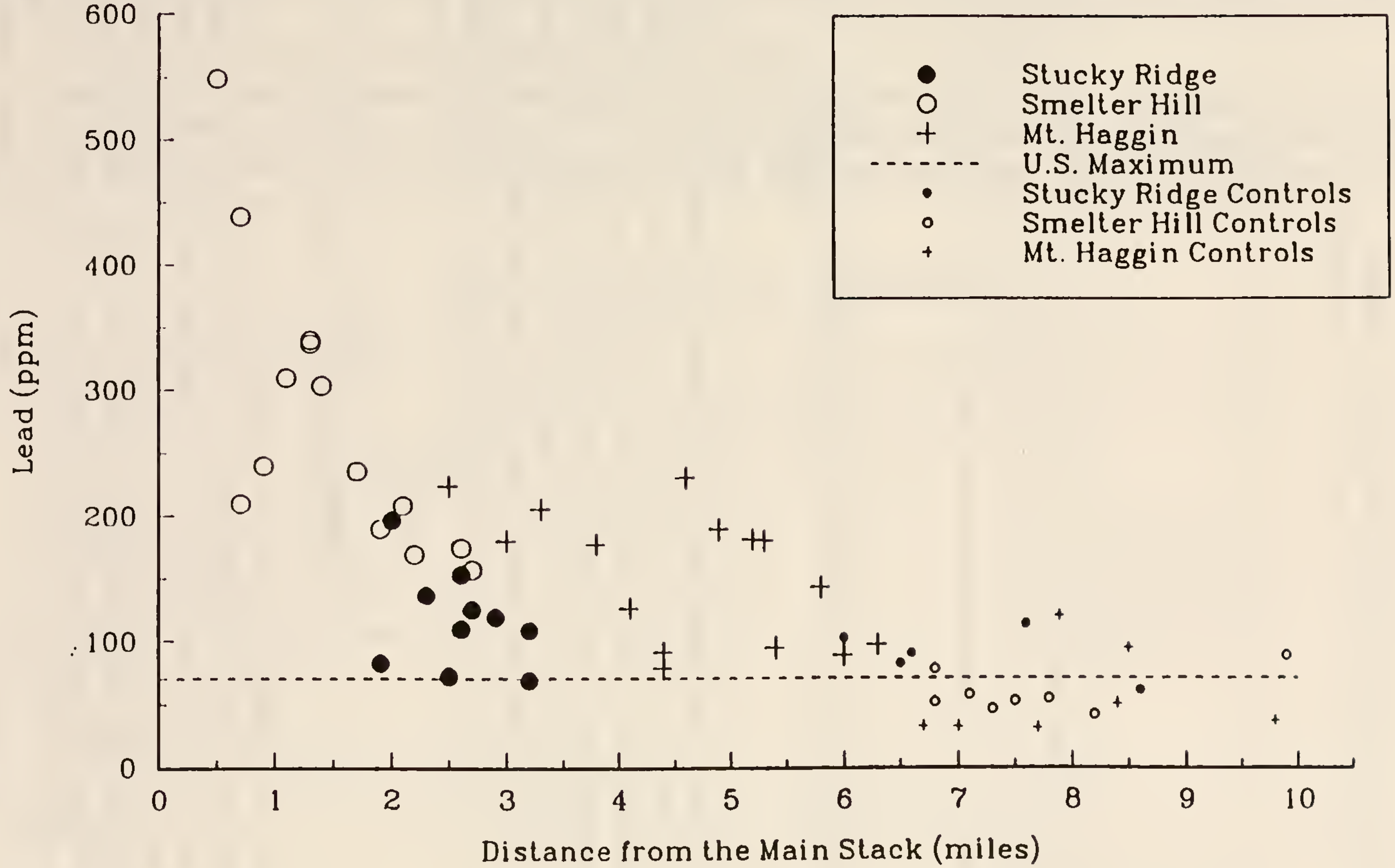

Figure 3-5. Lead Concentrations in Soils with Distance from the Main Smelter Stack. Data points are total lead (ppm) in soils collected from the Stucky Ridge, Smelter Hill, and Mount Haggin impact areas, and the German Gulch control sites. The dashed line indicates the highest soil concentration considered to represent naturally occurring lead in soils of the United States (70 ppm) (Kabata-Pendias and Pendias, 1992).

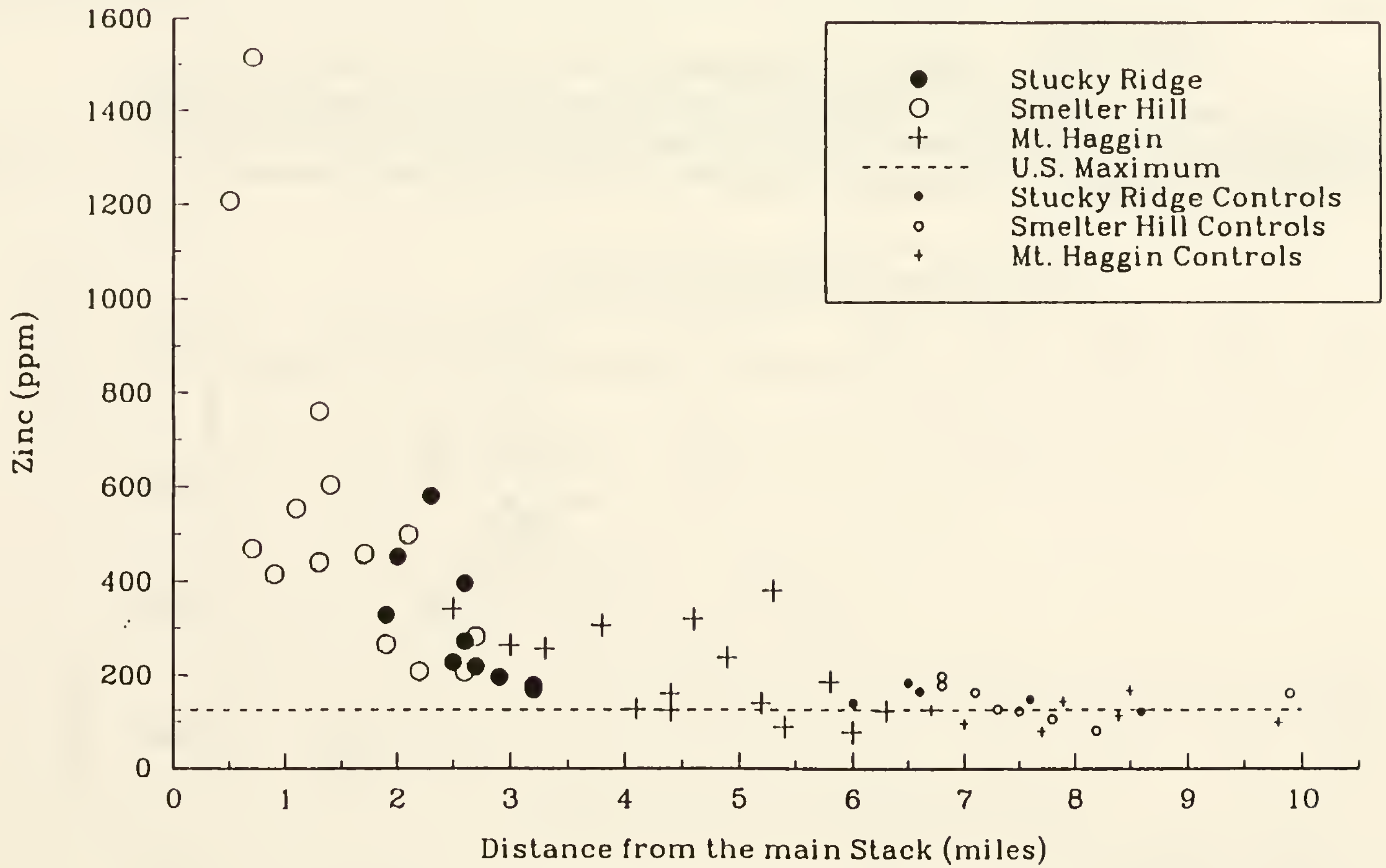

Figure 3-6. Zinc Concentration in Soils with Distance from the Main Smelter Stack. Data points represent total zinc in 0-2 inch soils collected from the Stucky Ridge, Smelter Hill, and Mt. Haggin impact areas, and from the German Gulch control sites. The dashed line indicates the upper end of the range of mean zinc concentration in uncontaminated soils (17 - 125 ppm) (Kabata-Pendias and Pendias, 1992).

Table 3-5
Results of Randomized Regression Analysis[1] of Metals Concentrations with Distance from the Smelter Hill Main Stack

Element	β_1	p-value
Arsenic	-0.739×10^2	0.0002*
Cadmium	-0.190×10^1	0.0002*
Copper	-0.186×10^3	0.0002*
Lead	-0.279×10^2	0.0002*
Zinc	-0.623×10^2	0.0002*

[1] Reported slope (β_1) of the observed data regression, and the probability of the slope equalling zero (p-value) derived from comparison of regression coefficients from 5,000 random simulations.
* Indicates significant at $\alpha < 0.001$.

3.1.7 Control Sample Concentrations Relative to Concentrations in Uncontaminated U.S. Soils

The German Gulch area was selected as a general control area based on its proximity and its similarity in elevation and overall aspect to the impact area. Means and ranges of arsenic, cadmium, copper, lead, and zinc for the soils sampled were greater than U.S. means, and copper and cadmium were greater than reported ranges for uncontaminated U.S. soils. However, the control soils contained significantly lower concentrations of hazardous substances than did most of the impact area soils. These results indicate that soils in the German Gulch area were most likely also exposed to aerial deposition of emissions from the Anaconda smelter. Therefore, German Gulch mean values (Table 3-6) are conservative baseline values.

3.1.8 Soil Nutrients, Ancillary Parameters

Twenty three of the 0 to 5 cm impact soils and eight control soils, including all soils used in phytotoxicity tests (Appendix B) plus three impact soils that were not used in the phytotoxicity tests, were analyzed for pH, percent sand, silt, clay, and organic matter, concentrations of nitrate, phosphorous, and potassium, and CEC. Results from control and impact sites were compared to test for differences in soil parameters other than hazardous substances which affect plant growth performance. The null hypothesis, of no difference in any of the above between impact and control soils, was accepted for all parameters except organic matter ($p < 0.05$; Table 3-7).

Table 3-6
Baseline Concentrations of Hazardous Substances in Anaconda Area Soils and Background Concentrations Reported for U.S. Soils

	Arsenic	Cadmium	Copper	Lead	Zinc
Baseline Concentrations (German Gulch)*					
Range	47.2 - 136.4	1.3 - 5.1	58.6 - 236.5	31.1 - 119.7	78.4 - 196.3
Mean	89.5	3.0	148.4	68.1	135.9
U.S. Background Concentrations[1,2]					
Range	< 0.1 - 93	0.005 - 2.4	1 - 100	10 - 70	17 - 125
Mean	10	0.53	25	32	64

[1] Kabata-Pendias and Pendias, 1992
[2] Alloway, 1990
* Baseline concentrations were measured in German Gulch area (0-2 inch soils).

Table 3-7
Comparisons of Mean Soil Nutrient Concentrations (ppm), pH, CEC (meq/100g), % Organic Matter, and % Particle Size in Impact and Reference 0 to 5 cm Soils

Variable	Reference Samples n = 8	Impact Samples n = 23	p-value
Potassium	609.7	501.6	0.4538
NO_3-nitrogen	1.8	4.7	0.0904
Phosphorous	137.1	139.4	0.9358
pH	5.7	5.4	0.2908
CEC	16.4	16.0	0.8888
% Organic Matter	6.4	3.9	0.0078*
% Sand	59.6	56.5	0.5124
% Silt	25.2	24.3	0.7562
% Clay	16.1	18.8	0.2310

Note: * indicates a significantly greater amount in reference soils (α = 5%; 2-tailed tests).

3.1.9 Results Summary

Mean soil concentrations of total arsenic in upland impact sites ranged from 2.98 to 6.66 times higher than the mean concentrations in upland control areas. Mean concentrations of total cadmium ranged up to 6.16 times higher than control site mean values. Mean concentrations of total copper exceeded control site mean values by up to 8.6 times. Mean concentrations of total lead were as much as 4.7 times higher than in control sites, and mean concentrations of zinc were up to 3.98 times higher (Table 3-1).

The mean (and sometimes even the minimum) values of arsenic, cadmium, copper, and zinc for all samples collected in impact areas exceed the ranges of values reported in the literature for typical uncontaminated soils (Figures 3-2 through 3-6).

Arsenic

Arsenic concentrations in the control samples were near the high end of the range reported in the literature as occurring naturally. Regression results (Table 3-5) confirmed that soil arsenic concentrations tend to decrease with increasing distance from the stack. Figure 3-2 does not account for direction, but all control samples were taken to the south of the stack. By 7 miles to the south, topsoil concentrations of arsenic are near the high end of the range of literature baseline values. The pattern illustrated in Figure 3-2 suggests that German Gulch was within the range of exposure to smelter emissions and deposition, though to a lesser extent than Stucky Ridge, Smelter Hill, and the Mount Haggin area.

Cadmium

Cadmium concentrations in impact and control soils exceeded naturally occurring levels reported in the scientific literature. As far as 10 miles from the stack, cadmium concentrations in topsoils are considerably elevated above typical U.S. values (Figure 3-3). Since the Anaconda Soil Investigation (PTI, 1992) found numerous soil cadmium concentrations in the regional and community soils within the range of values cited for uncontaminated U.S. soils (i.e., < 2.4 ppm), it is unlikely that the elevated concentrations observed are attributable to the parent material in German Gulch. The evidence (decreasing concentration with distance) suggests that soils in the German Gulch area have been contaminated with cadmium via smelter emissions; thus the control sites selected provide a conservative baseline.

Copper

Copper concentrations in control and impact areas were all elevated relative to uncontaminated soil concentrations reported in the United States. Mean concentrations in impact area soils were elevated at least 13 times the high end of the range reported for native U.S. soils, and the maximum value reported in the upland impact area, 1846.70 ppm, exceeds

the maximum literature values by at least 18 times. Mean control site copper concentrations were elevated up to two times maximum naturally occurring concentrations. Copper concentrations exhibit an exaggerated decrease with distance from the stack (Figure 3-4). The highest concentrations were determined in samples from Stucky Ridge and Smelter Hill, decreasing with distance in the Mount Haggin samples.

Lead

Lead concentrations in upland impact area soils averaged well above values reported for uncontaminated U.S. soils, and several control samples exhibited elevated concentrations as well. There is an obvious decline in soil lead concentration beyond 5 miles to the south of the main smelter stack (Figure 3-5). The extreme concentrations on Smelter Hill may be due to contamination by fugitive emissions from waste piles.

Zinc

All concentration values for zinc from Stucky Ridge or Smelter Hill soils exceeded the range of naturally occurring mean zinc concentration (125 ppm). Soils from the most distant sites in Mount Haggin exhibited zinc concentrations within the expected range. Concentrations of zinc in several of the control area soils were elevated above the United States near range as well. Again, the decreasing concentration with distance from the stack indicates that the Anaconda smelter was the principal source of releases (Figure 3-6).

3.2 RIPARIAN SOILS

3.2.1 <u>Impact Versus Control Reach Concentrations</u>

Summary statistics for riparian impact and control reaches are presented in Table 3-8; raw data are provided in Attachment B.

Mean arsenic concentrations in impact reach soils ranged from 396.4 ppm in the Opportunity Ponds to 264.1 ppm in lower Silver Bow Creek; mean arsenic concentrations for control reaches ranged from 87.6 ppm for Flint Creek to 27.5 ppm for Divide Creek. In order of decreasing mean arsenic concentration, the impact and control reaches rank as follows:

> Opportunity Ponds > the upper Clark Fork River > upper Silver Bow Creek > lower Silver Bow Creek >> Flint Creek > Little Blackfoot River > Divide Creek

Mean cadmium concentrations for the impact reach soils ranged from 14.7 ppm for the Opportunity Ponds to 4.7 ppm for the upper Clark Fork River; mean cadmium concentrations for control reaches ranged from 0.7 ppm for the Little Blackfoot to 1.7 for Divide Creek. In order of decreasing mean cadmium concentration, the impact and control reaches rank as follows:

Table 3-8
Summary Statistics for Riparian Impact and Control 2-Inch Soils Samples
(total metals in ppm)

Sample Identification		As	Cd	Cu	Pb	Zn
Upper Silver Bow Creek	n = 6					
Arithmetic mean		374.6	8.8	1361.0	591.1	2816.6
Maximum		509.0	17.8	4014.0	885.8	5108.0
Minimum		274.3	3.7	478.0	392.0	1460.9
Standard deviation		81.1	5.1	1252.3	178.5	1399.3
Divide Creek (control)	n = 6					
Arithmetic mean		27.5	1.7	43.4	26.2	92.3
Maximum		76.4	5.8	56.4	40.0	136.0
Minimum		10.0	0.5	28.7	17.3	67.3
Standard deviation		22.2	1.9	12.3	8.2	25.8
Lower Silver Bow Creek	n = 6					
Arithmetic mean		264.1	5.0	905.5	477.5	1504.3
Maximum		425.6	8.3	1414.5	836.6	2152.0
Minimum		163.6	1.7	407.5	307.3	720.5
Standard deviation		110.5	2.5	408.3	195.6	590.5
Little Blackfoot (control)	n = 5					
Arithmetic mean		28.1	0.7	25.0	45.6	111.9
Maximum		44.1	1.4	43.6	100.1	169.7
Minimum		12.5	0.3	13.8	19.1	62.4
Standard deviation		12.9	0.4	10.5	26.6	39.3
Upper Clark Fork River	n = 5					
Arithmetic mean		391.3	4.7	2012.6	292.6	1230.3
Maximum		525.5	8.5	3644.0	360.0	1607.2
Minimum		291.8	1.1	566.5	236.8	549.5
Standard deviation		92.1	2.4	987.8	49.3	359.9
Flint Creek (control)	n = 5					
Arithmetic mean		87.6	1.2	49.9	127.8	349.7
Maximum		145.4	1.9	72.8	205.7	523.8
Minimum		36.6	0.6	28.2	51.2	194.4
Standard deviation		39.7	0.6	17.3	60.3	134.6
Opportunity Ponds	n = 5					
Arithmetic mean		396.4	14.7	2353.4	301.9	738.3
Maximum		1398.1	68.1	9980.0	722.6	2676.0
Minimum		18.5	0.7	301.6	54.2	68.0
Standard deviation		506.5	26.7	3816.3	257.2	977.7

Opportunity Ponds >> upper Silver Bow Creek > lower Silver Bow Creek > the upper Clark Fork River >> Divide Creek > Flint Creek > Little Blackfoot River

Mean copper concentrations for impact reach soils ranged from 2353.4 ppm for the Opportunity Ponds to 905.5 ppm for lower Silver Bow Creek; mean copper concentrations for control reach soils ranged from 49.9 ppm for Flint Creek to 25.0 ppm for the Little Blackfoot River. In order of decreasing mean copper concentration, the impact and control reaches rank as follows:

Opportunity Ponds > the upper Clark Fork River > upper Silver Bow Creek > lower Silver Bow Creek >> Flint Creek > Divide Creek > Little Blackfoot River

Mean lead concentrations for impact reach soils ranged from 591.1 ppm for upper Silver Bow Creek to 292.6 ppm for the upper Clark Fork River; mean lead concentrations for control reach soils ranged from 127.8 ppm for Flint Creek to 26.2 ppm for Divide Creek. In order of decreasing mean lead concentration, the impact and control reaches rank as follows:

upper Silver Bow Creek > lower Silver Bow Creek > Opportunity Ponds > the upper Clark Fork River >> Flint Creek > Little Blackfoot River > Divide Creek

Mean zinc concentrations for impact reach soils ranged from 2816.6 ppm for upper Silver Bow Creek to 738.3 ppm for Opportunity Ponds; mean zinc concentrations for control soils ranged from 349.7 ppm for Flint Creek to 92.3 ppm for Divide Creek. In order of decreasing mean zinc concentration, the impact and control reaches rank as follows:

upper Silver Bow Creek > lower Silver Bow Creek > the upper Clark Fork River > Opportunity Ponds >> Flint Creek > Little Blackfoot River > Divide Creek

3.2.2 Impact Stream Concentrations Versus Baseline Concentrations

Soil concentrations from paired impact and control transects were compared using two-sample randomization tests (5,000 randomizations) (Manly, 1991). These tests showed that concentrations of arsenic, cadmium, copper, lead, and zinc were significantly higher in the riparian impact soils than in their respective controls (Table 3-9). These relationships are presented in Figure 3-7, which illustrates mean concentrations and standard deviations of hazardous substances impact and control reaches.

Differences in observed sample means from the Opportunity Ponds ($n = 5$) and all riparian control soils ($n = 17$) were compared by the two sample randomization test (Manly, 1991). Concentrations of arsenic, copper, lead, and zinc in Opportunity Ponds samples were significantly greater than in riparian control samples (Table 3-10). Cadmium concentrations were greater than controls for $\alpha < 0.06$.

Table 3-9
Two-Sample Randomization Test Comparing Impact and Control Reaches

Test	Upper Silver Bow Creek vs. Divide Creek n = 6 pairs		Lower Silver Bow Creek vs. Little Blackfoot n = 6 pairs		Upper Clark Fork River vs. Flint Creek n = 5 pairs	
Element	Mean Difference	p-value	Mean Difference	p-value	Mean Difference	p-value
Arsenic	347.68	0.001*	235.97	0.0012*	303.66	0.0034*
Cadmium	7.18	0.0042*	4.32	0.0012*	3.42	0.0178*
Copper	1317.28	0.0014*	880.43	0.0014*	1962.7	0.0038*
Lead	564.87	0.0002*	431.88	0.0012*	166.6	0.0046*
Zinc	2725.25	0.001*	1392.33	0.0006*	880.6	0.001*

* Indicates significantly higher concentration in impact reach for α = 3.3%.

Table 3-10
Results of the Two-Sample Randomization Test Comparing Opportunity Ponds Soils Concentrations with Riparian Control Reach Soils Concentrations

Element	Mean Difference	p-value
Arsenic	351.0176	0.0014*
Cadmium	13.5259	0.056**
Copper	2314.548	0.0002*
Lead	238.9471	0.0064*
Zinc	563.3906	0.0358*

* Indicates greater concentration in the Opportunity Ponds at α = 5%.
** Indicates greater concentration in the Opportunity Ponds at α = 6%

Average concentrations and ranges over all three control streams are presented in Table 3-11. The control reaches do not represent pristine riparian soils; the control streams were selected based on primary physical features, regardless of current land use. Thus, all of the control stream samples represent a random sample of soils subjected to various land uses and associated impacts. Two of the control reaches (particularly Flint Creek) have been exposed to mining-related impacts, but to a lesser degree than the impact reaches; baseline has been established as the average concentrations of arsenic, cadmium, copper, lead, and zinc measured in the six samples from Divide Creek and the six samples from the Little Blackfoot River (see Chapter 6.0).

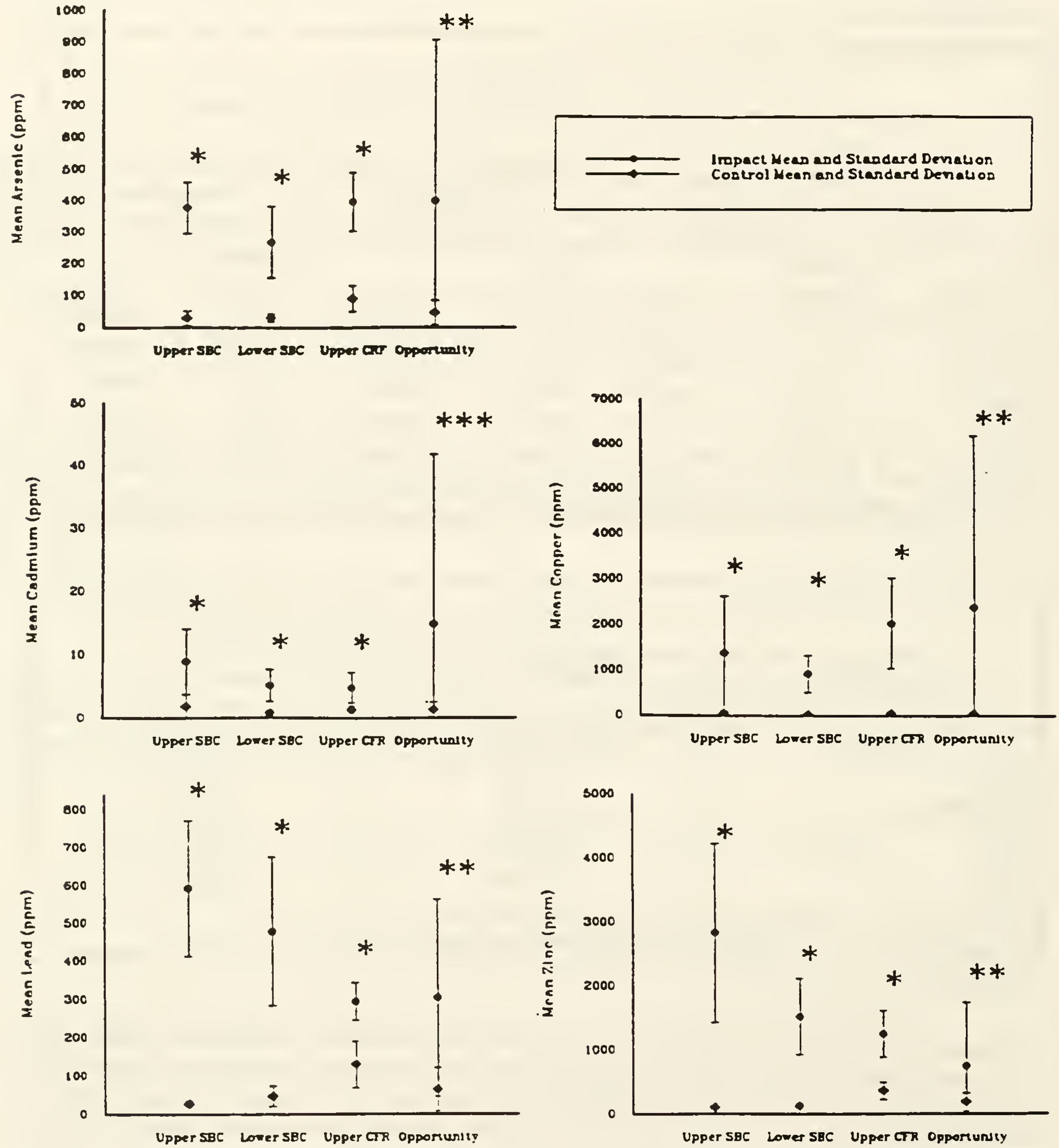

Figure 3-7. Mean Concentrations of Hazardous Substances in Impact and Control Reach Soils. Error bars represent the standard deviation on the mean. * indicates means that were significantly different at the α = 3.3% level. ** and *** indicate means that were significantly different at α = 5% and at α = 6%, respectively.

Table 3-11
Control Concentrations of Hazardous Substances in Riparian Soils and Floodplain Sediments (ppm)

	Arsenic	Cadmium	Copper	Lead	Zinc
Range	10.0 - 145.4	0.3 - 5.8	13.8 - 72.8	17.3 - 205.7	62.4 - 523.8
Mean	47.7	1.2	39.4	66.5	184.6
Concentrations were measured in Divide Creek, Little Blackfoot River, and Flint Creek soil samples.					

Means for arsenic concentrations in each of the impact reaches exceeded the means in the control reaches by 4.5 to 13.7 times. Cadmium concentration means in the control streams were exceeded by 3.8 to 7.2 times in the impact reaches; copper by 10 to 40 times; lead 2.2 to 22.5 times, and zinc by 3.5 to 30.5 times in the impact reaches.

Arsenic concentrations measured in control reaches fell within the range of U.S. baseline values for soils (< 0.1 to 93 ppm), but all arsenic concentrations determined in impact reach samples exceeded the upper end of the range (93 ppm) by two to three times.

Moore et al. (1989) estimated arsenic baseline for the Clark Fork floodplain sediments to be 26.5 ppm based on 24 floodplain samples from the Clark Fork tributaries (see also Lipton et al., 1995). Divide Creek and Little Blackfoot values correspond well with that estimate (see Table 3-11), but Flint Creek samples were enriched with arsenic.

Cadmium concentrations on control streams were within or near the upper end of the range considered baseline for U.S. soils (0.06 to 1.1 ppm). Moore et al. (1989) estimated a cadmium baseline value for the Clark Fork floodplain sediments to be < 2.5 ppm (see also Lipton et al., 1995). Cadmium concentrations in impacted riparian soils greatly exceeded those in control soils, and exceeded the high end of the U.S. baseline range (1.1 ppm) by as much as 17 times.

Copper concentrations in the riparian impact reaches ranged from 407.50 to 4014.00 ppm, concentrations which exceed the U.S. uncontaminated range for soils (100 ppm) by 4 to 40 times. The baseline copper concentration reported by Moore et al. (1989) for 24 floodplain soils was 27.5 ppm (see also Lipton et al., 1995); values measured on control streams in this study ranged as high as 72 ppm, but averaged 43.4 ppm, 25.0 ppm, and 49.9 ppm for Divide Creek, Little Blackfoot River, and Flint Creek, respectively.

Lead concentrations in riparian impacts soils were up to 12 times higher than the maximum value considered to be naturally occurring soil lead (70 ppm). Lead concentrations determined for riparian control soils were mainly below 70 ppm, with some exceptions on Flint Creek. Zinc concentrations in soils range from 17 to 125 ppm. Zinc concentrations in riparian impact soils exceeded control the upper end of the control range by as much as 40 times. Control area concentrations of zinc were within the U.S. baseline range for Divide Creek and Little Blackfoot River, but were double to triple the high end of that range for Flint Creek.

For all three pairs of reaches, impact soils contained significantly greater concentrations of hazardous substances than control stream soils.

3.2.3 Distribution of Hazardous Substances with Distance Downstream

The concentration ranking series presented in Section 3.2.1 suggest the absence of a dilution trend with distance downstream. The concentration data indicate that slickens composition (i.e., concentrations of hazardous substances) is highly variable within an elevated range, but mixing and dilution of existing tailings with distance from the source is not ameliorating the elevated concentrations. The absence of trend is illustrated in Figure 3-8.

Figure 3-9, a series of frequency-of-concentrations-measured histogram, clearly shows that for slickens, there is a minimum concentration bound. The same minimum bound is not observed in the distributions of control sample concentrations. Figure 3-9 supports the hypothesis that slickens composition is comparatively uniform and lends confidence to the assertion that all slickens not sampled, including those in Silver Bow Canyon and on the Clark Fork River downstream from Deer Lodge, are fundamentally similar in composition to those slickens that were randomly sampled. Further, there is no mechanistic or chemical reasoning to expect un-sampled slickens to differ significantly in phytotoxicity and soil injury.

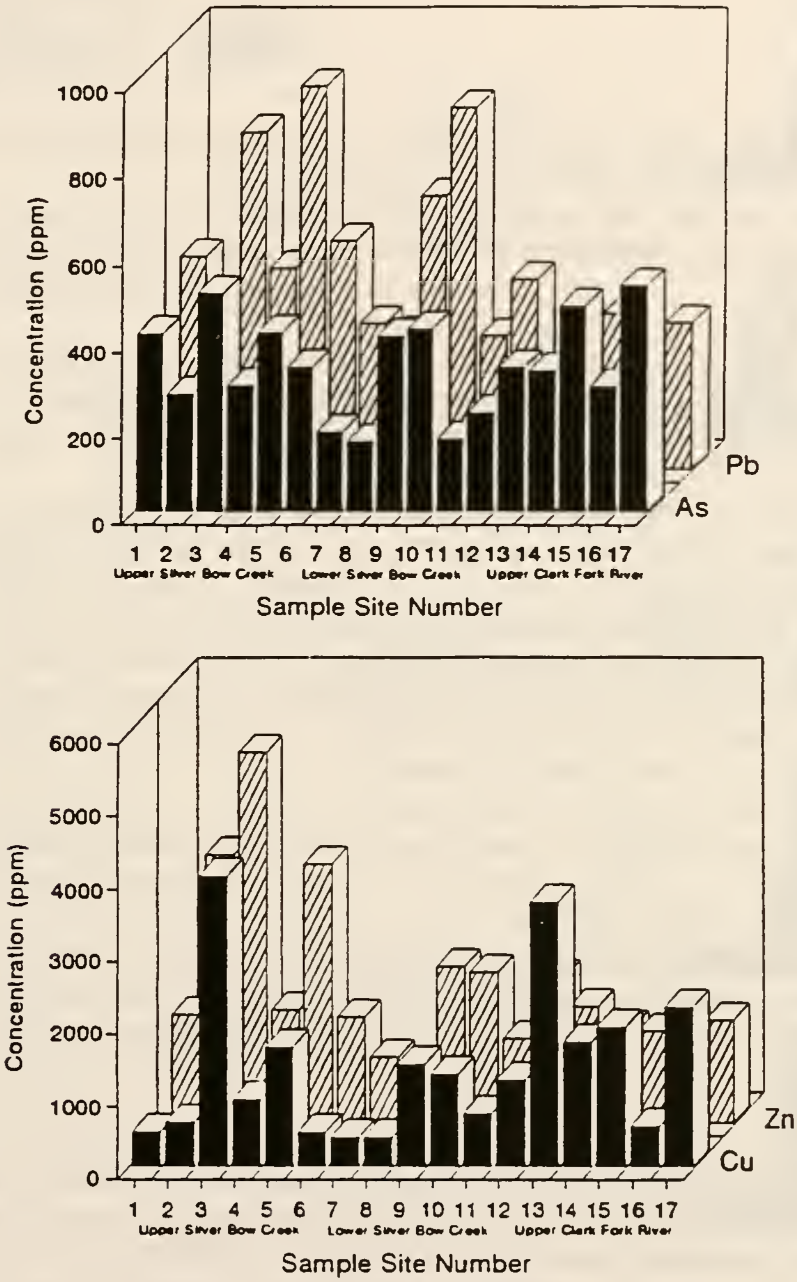

Figure 3-8. Concentrations of Each Element at Sample Points Collected Within Each Impact Reach. Sample point concentrations are plotted in a downstream direction; the axis is not scaled to show linear distance. The series of figures illustrates the absence of trend in concentration of hazardous substances with distance downstream.

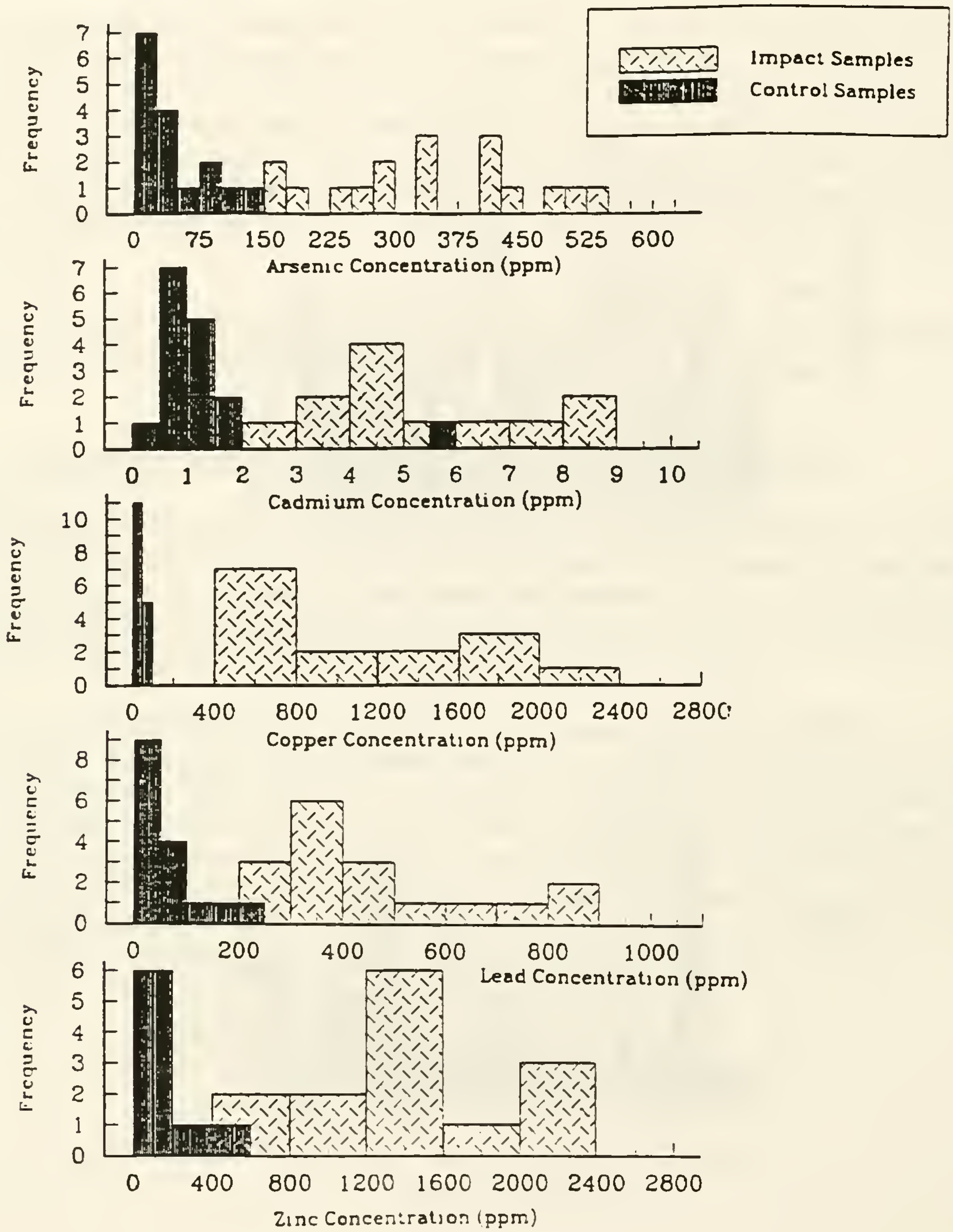

Figure 3-9. **Frequency Diagrams Illustrating the Difference in Hazardous Substance Concentration Ranges of Riparian Impact and Control Samples.** These histograms illustrate the common chemical composition of the slickens samples, and the relative difference from the common chemical composition measured in baseline riparian soils.

4.0 CONCLUSIONS

4.1 UPLAND SOILS

The results of the soil sampling support the following conclusions:

- Concentrations of the hazardous substances arsenic, cadmium, copper, lead, and zinc in the delineated impact areas (17.8 square miles) are significantly elevated relative to control area soils.

- Concentrations of hazardous substances are greatest in the top 2 inches of the soil, suggesting an aerial source of anthropogenic origin (e.g., smelter emissions, fugitive emission from waste piles).

- Concentrations of hazardous substances in the surface soil decrease with distance from the smelter stack. Between 6 and 7 miles, concentrations are generally within the high end of the ranges reported as baseline for typical uncontaminated U.S. soils (Kabata-Pendias and Pendias, 1992; Alloway, 1990). Long-distance transport of hazardous substances has resulted in widespread regional contamination of soils, which confounds identification of natural baseline levels.

- Local baseline concentrations (average concentrations of German Gulch control samples) provide a very conservative baseline since these soils were also exposed to deposition of smelter emissions.

- Concentrations of soil nutrients, pH, CEC, and percentages of sand, silt, and clay in control and impact soils did not differ significantly, and thus are unlikely to explain differences in vegetation communities in the impact and control areas.

The three impact areas identified, Stucky Ridge, Smelter Hill, and Mount Haggin, were delineated based on the criteria described in Section 2.1.2 of this appendix, and were identified as distinct areas for sampling purposes. In terms of concentrations of hazardous substances expected in the soils in the ***absence*** of mining-related influence, there is no a priori reason to expect differences between the three areas, and in terms of the injury resulting from deposition of hazardous substances rendering soils phytotoxic, there is also no reason to expect differences by area. The test comparing ***all*** upland impact areas with ***all*** control areas confirms the significantly greater contamination in the impact areas.

4.2 RIPARIAN SOILS

- Soil samples collected from unvegetated slickens along Silver Bow Creek and the Clark Fork River have significantly elevated concentrations of arsenic, cadmium, copper, lead, and zinc relative to control samples collected from Divide Creek, Little Blackfoot River, and Flint Creek.

- Soil concentrations of arsenic, cadmium, copper, lead, and zinc in slickens samples do not show a consistent decrease with distance downstream within the span of this study, indicating that dilution with native alluvium is not functioning to alleviate contamination of the slickens present in the range of this study.

- Concentrations of hazardous substances in the slickens sampled are consistently elevated and exhibit a common chemical composition relative to baseline samples. The relatively uniform elevation in concentration of hazardous substances is characteristic of slickens composition; the slickens sampled for this study are representative of slickens composition throughout the length of Silver Bow Creek, and likely along much of the Clark Fork River.

4.3 IMPLICATIONS

Contamination of soils by metals and metalloids is considered virtually permanent and irreversible (Kabata-Pendias and Pendias, 1992). There are no natural degradation processes for the hazardous substances with which these soils are contaminated; soil recovery depends on leaching of metals to subsurface soil horizons, erosion or dilution of contaminated soils, or uptake and adsorption processes which bind contaminants in unavailable forms.

The elevated concentrations determined have significant implications for ecological processes dependent on the soil resource. Of the hazardous substances identified, copper and zinc are essential to plants at very low concentrations, but become toxic at higher concentrations (Alloway, 1990). Arsenic, cadmium, and lead have no role in plant metabolism, and their accumulation in plants is toxic (Kabata-Pendias and Pendias, 1992). All available evidence indicates that elevated concentrations of trace minerals in soils are toxic to soil microbiota, particularly the organisms involved in nitrogen cycling in soils (Kabata-Pendias and Pendias, 1992). Disruption of biogeochemical cycles in the soil resource will continue to inhibit biological processes instrumental in soil formation, native plant regeneration and growth in the impacted areas, and recovery of the soil-plant-animal ecosystem.

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ATTACHMENT A

Soil Sampling Protocols: Montana NRDA

SOIL SAMPLING PROTOCOLS: MONTANA NRDA

1) Materials Needed

- shovel with carbon steel blade
- stiff brush (for cleaning shovel)
- squirt bottle of dilute liquinox
- squirt bottle of DI water
- scrubbies
- small sample bags (3 inch x 7 inch)
- large sample bags (4.5 inch x 12 inch) with separate adhesive labels
- scoops
- gloves
- 6-inch ruler
- pens (sharpie & ballpoint)
- field notebook
- 300 ft. (91.4 m) measuring tape (for riparian control areas only)
- Whatman™ filter papers (for QA/QC transects).

2) Decontamination

The shovel shall be decontaminated before starting a new transect. After locating the transect and arriving at the first sampling flag, brush the shovel to remove any leftover soil from a previous transect. Decontaminate the shovel by spraying thoroughly with liquinox solution, scrubbing the shovel head with a scrubby, then rinsing thoroughly with DI water. Allow shovel to dry (if possible) before digging sample. Care shall be taken to decontaminate downwind and away from the sampling area.

3) Taking the Sample

A1) Chemistry Site - Upland

All chemistry sites require taking soil samples from a depth of 0-2 inches. Enough sample shall be taken to fill a small sample bag. Samples shall be taken north of the flag in line with the transect. The hole shall be dug one shovel head length from the flag. If there is an obstruction, the hole shall be relocated (in this order): 1) two shovel head lengths north of the flag; 2) one shovel head length south of the flag, in line with the transect. If there is still no suitable area from which to sample, the hole shall be placed within 1 meter of the flag, as close to the line of the transect as possible. If a sample location must be moved because of an obstruction, the location sample hole in relation to the flag shall be noted in the field notebook.

The sample hole for a chemistry site shall be large enough to easily sample 2 inches below the surface. One side shall be cut as a vertical face. Either a shovel or a dedicated scoop may be used to dig the hole, as appropriate. Surface vegetation and leaf litter shall be scraped away (using the shovel or the scoop) so that the soil surface is exposed.

The sample shall be taken using a scoop. Remove the scoop from the sealed plastic wrapper; discard any scoop that has had the wrapper opened before the start of sampling at one transect. One scoop may be used for all five 0-2 inch sites because those samples will be composited. After scooping a sample, the scoop shall be returned to its plastic wrapper to avoid contamination of other items in the pack.

Before filling a small sample bag, the white area on the bag shall be labeled with the following information using a Sharpie waterproof marker: sample name (i.e., "CC12-3-2," where "CC12" refers to the twelfth transect in the area CC, "3" refers to sample number three within the transect, and "2" refers to the maximum depth of the sample), names of the samplers, number of samples bearing the same name (i.e., 1 cof 1), date and time of sample, and 4°C preserve. Note that flags in control areas are labeled exactly as those in the impact area, with the addition of "Ref." Since using "Ref" may imply a bias in the laboratory, the first letter of a control area sample label shall be doubled, and "Ref" shall NOT be written (i.e., "A1-3 Ref" becomes "AA1-3"). The last digit of the label refers to the depth from which the sample was taken. Since all chemistry sites are taken from 0-2 inches, the last digit shall be 2 (i.e., "AA1-3-2"). The sample bag shall be filled full, leaving enough room to twist the top wire completely to insure that sample will not leak from the sample bag.

A glove shall be worn when collecting soil samples. Only the gloved hand shall be used to pick out stones and sticks from a sample. If there is a limited number of gloves, the same glove can be used for all five 2-inch holes. Between sample points on the transect, the used glove shall be stored in the plastic wrapper containing the scoop. The used glove shall NOT be placed with the unused gloves, because that may contaminate all the other gloves.

The ruler shall be used to measure the depth to which the sample extends. The depth shall be measured frequently to insure accuracy of the 2-inch maximum depth.

After the sample has been collected, the hole shall be refilled. At the start of the next sample on the same transect, the shovel shall be cleaned using the brush.

Once all five sample points along the transect have been finished, all used gloves and scoops shall be deposited in a garbage receptacle that shall be separate from the unused gloves and scoops.

A2) Chemistry Site - Riparian

The protocol for riparian chemistry sites shall follow that of the upland chemistry sites, with the following change:

1) the location of the sampling hole shall be one shovel head length from the flag, in line with the transect, on the side of the flag opposite of the river. The protocol for relocating a sampling point because of obstruction is the same as for upland sites.

B) Screening Site - Upland and Riparian

A screening site shall be sampled exactly as a chemistry site for both upland and riparian areas, with the exception that one large sample bag shall be filled. The label on the large bag shall contain the same information as that on the small bag, but the information shall be written on a yellow adhesive label and pasted onto the sample bag.

C1) Phytotoxicity Site - Upland

If the site is designated as a phytotoxicity site, a hole for a 0-2 inch soil sample shall be located and dug as described for a chemistry site, only the hole shall be 15-20 inches wide to accommodate a larger sample size. A second hole for 0-6 inch samples shall be dug one full shovel length north of the 0-2 inch hole and in line with the transect. Relocation either hole in the event of an obstruction shall follow the same protocol as described for the 0-2 inch chemistry hole. The 0-6 inch hole shall be large enough to accommodate two large bags of soil sample.

Two scoops shall be used for phytotoxicity sites; one scoop shall be used exclusively for 0-2 inch samples along the transect, and one scoop shall be used exclusively for 0-6 inch samples along the transect. It is very important to label the plastic wrappers for the scoops to avoid confusing the 0-2 inch and the 0-6 inch scoop.

A separate glove shall be used when handling samples from 0-2 inch holes and samples from 0-6 inch holes. If gloves must be conserved, the glove for the 0-2 inch holes shall be stored in the plastic wrapper with the 0-2 inch scoop, and the glove for the 0-6 inch hole shall be stored in the plastic wrapper with the 0-6 inch scoop.

Sample labels shall be filled as described for chemistry sites. Large bags will be used for all phytotoxicity samples; therefore, the yellow adhesive sample bag labels shall be used. One large bag shall be filled with 0-2 inch sample; thus, the label shall show indicate "1 of 1" samples collected at, for example, "A1-1-2." Two large bags shall be

filled with 0-6 inch sample; thus, the labels shall indicate "1 of 2" and "2 of 2" samples collected at "A1-1-6."

For both the 0-2 inch and the 0-6 inch samples, the ruler shall be used frequently to measure the maximum depth at which the sample is being taken. It is important that the samples be a composite of all soil between the soil surface (0 inches) and the maximum depth (2 inches or 6 inches).

C2) Phytotoxicity Site - Riparian

The protocol for phytotoxicity sampling at riparian sites shall follow that of the upland sites, with the following exception:

1) The location of the 0-2 inch sampling hole shall be one shovel head length from the flag on the side opposite the river, and the 0-6 inch sampling hole shall be one full shovel length from the 0-2 inch hole, in the direction opposite of the river. The protocol for relocating sampling holes due to obstruction are exactly the same as for upland phytotoxicity sites.

4) Recording Information in the Field Notebook

The field notebook shall contain the following information about the sampling as it progresses:

1) The transect number (i.e., AA3)

2) The names of the sample collector, field recorder, and observer(s)

3) The subsample (i.e., AA3-1)

4) The time that each sample is collected

i.e.,	AA3-1-2	11:10 AM	1 of 1
	AA3-1-6	11:15 AM	1 of 2
	AA3-1-6	11:17 AM	2 of 2

5) A brief description of the sampling area, including any pertinent soil and vegetation characteristics, presence of deadfall, etc.

6) A description of the exact location of the sample holes with respect to the flag, if the sample hole has been moved due to an obstruction;

7) A description of the condition of the flag if the flag was found lying on the ground, tampered with, eaten, etc.

8) The top of each page in the field notebook shall have the date; the bottom of each page shall be signed or initialed by the person recording in the book.

5) Protocol for Missing Flags

If a flag indicating a sample point cannot be located on a transect, the following steps shall be taken:

1) IF the missing flag falls between two existing flags, AND the two existing flags can be seen from an approximate midpoint, then sample point shall be estimated as the visual midpoint between the existing points on the transect.

2) IF the missing flag is one of the endpoints on the transect (i.e., subsample number 1 or 5), OR if the preceding and proceeding flags cannot both be seen from the midpoint, then the distance between two existing flags on the transect shall be paced, and that number of paces shall be walked along the transect to place the missing sample point. All upland transect follow a compass bearing of 345°; that heading shall be followed when pacing to relocate a flag.

It is imperative that an estimated flag location be recorded in the field notebook.

6) Protocol for Flagging Transects Prior to Sampling

Some riparian control sites require the soil sampling team to flag the transect at the time of sampling. The following procedure shall be used for flagging the riparian control sites:

1) Locate the start of the transect by finding the marked trees and the first sampling flag along the river

2) starting at the bank of the river, lay out transect perpendicular to the river. The transect should be 100 meters long at Divide Creek and Flint Creek, and 120 meters long at Little Blackfoot River

3) The first flag will be located between 1 and 10 meters from the bank (see below); subtract that distance from the bank from the total transect length, divide by four, and round down to the nearest whole number. This number should be used for determining sampling interval (for example, if the first flag at a Divide Creek site is 9 meters from the bank, then the sample interval should be $[100-9]/4 = 22.75 \approx 22$ meters)

4) Place flags for the four remaining sample points at the intervals determined above. Thus, the above example, with 22 meter intervals after the first flag, will have sample points on the transect at 9, 31, 53, 75, and 97 meters.

If the first sample flag cannot be located along the river, the following steps shall be taken to establish the start of the transect:

1) Locate the transect area by corresponding physical features with features on the marked topographic map

2) Select a random or arbitrary number between 0 and 9

3) Place the first sample flag the distance (in meters) from the bank the corresponds to the random or arbitrary number selected (0 should be 10 meters from the bank)

4) Proceed flagging the transect as described above.

7) **QA/QC Transects**

Quality assurance/quality control (QA/QC) shall be included on five transects during the sampling, at a rate of approximately one QA/QC transect per twenty. QA/QC should be performed on chemistry sites according to the following protocol:

At the start of the QA/QC transect, decontaminate the shovel as described above. Place an unused disposable glove on one hand. When the shovel has dried, swipe the blade of the shovel with a piece of Whatman™ filter paper, holding the filter paper in the gloved hand. Be sure that the filter paper contacts much of the shovel blade. Place the filter paper in a small sample bag and seal as with soil. The bag shall be labeled with the transect number, "DB" for "decontamination blank," and "shovel" (i.e., C12-DB-SHOVEL). Dispose of the glove after the swipe is complete.

A decontamination blank for a scoop shall be performed as well. Open the plastic wrapper on a new scoop, place a new glove on one hand, and swipe the scoop with the gloved hand using another piece of filter paper. Put filter paper in a small sample bag and seal. Label the bag as for the shovel decontamination blank, inserting "scoop" for "shovel" (i.e., C12-DB-SCOOP). Discard glove when finished.

A final decontamination blank for the filter paper is also necessary. Using a new glove, place an unused piece of filter paper into a small sample bag. Label the bag as above, substituting "paper" for the last term (i.e., C12-DB-PAPER).
QA/QC on a chemistry site transect requires that triplicates be taken at each sample hole. Samples shall be taken exactly as described for chemistry sites, only the sample

hole shall be considerably larger to accommodate three small bags of sample per site. One scoop and one glove may be used for all samples, as described in section 3-A1. Sample bags shall be labeled exactly as for a regular chemistry site, with samples bags at each site labeled "1 of 3," "2 of 3," and "3 of 3."

At the conclusion of the QA/QC transect, open a large sample bag, then close it. The same shall be done with a small sample bag. These trip blanks shall be labeled as other samples are labeled, with the transect name and "TB" for "trip blank." The bags should be labeled as "1 of 2" and "2 of 2," respectively.

8) Sample Preservation

Once back at the truck, samples shall be put in coolers with blue ice, thus preserving at 4°C. Recheck to be sure that each sample bag is securely closed. Ice packs shall be changed twice per day until the samples are checked into the laboratory.

9) Chain of Custody

Chain of custody forms shall be completed at the conclusion of each sampling day. Each sample bag shall be sealed using an adhesive label. The seal should securely cover at least one corner of the tabs at the top of each sample bag. The sampler is responsible for the samples until the chain of custody form has been signed, relinquishing the responsibility to another person.

ATTACHMENT B

Analytical Soils Data, 1992

Sample	Depth (in)	As (ppm)	Cd (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	pH
Stucky Ridge							
A1	0−2	240.0	3.7	825.6	124.7	217.1	5.7
A2	0−2	222.7	3.2	662.8	108.3	177.1	6.6
A3	0−2	381.4	7.3	2856.0	136.6	580.5	8.1
A4	0−2	386.8	3.0	1024.0	119.0	194.9	
A5	0−2	624.3	5.0	2136.0	196.0	450.6	
A6	0−2	285.5	2.9	1179.2	109.6	271.0	5.5
A7	0−2	142.7	2.6	513.4	68.7	167.4	
A8	0−2	143.5	4.1	1062.5	82.4	327.7	8.0
A9	0−2	178.5	2.3	1515.7	71.9	226.7	
A10	0−2	429.6	4.2	1467.1	152.8	394.4	5.1
Smelter Hill							
B1	0−2	310.5	7.8	1010.2	156.8	281.5	
B2	0−2	278.5	7.6	691.5	174.0	205.1	5.6
B3	0−2	243.8	10.5	1049.9	207.8	497.5	7.1
B4	0−2	335.1	7.4	404.9	168.8	206.4	5.7
B5	0−2	183.3	13.5	963.0	235.2	456.5	6.9
B6	0−2	386.1	16.9	1658.2	303.4	603.8	
B7	0−2	778.4	19.5	2574.0	336.7	758.9	
B9	0−2	708.7	12.2	622.0	189.2	264.5	5.0
B10	0−2	615.5	15.6	845.3	339.6	439.6	
B11	0−2	658.0	16.1	1162.6	239.9	414.3	5.4
B12	0−2	496.0	9.3	1408.9	209.6	468.7	5.7
B13	0−2	660.6	20.4	749.7	309.6	553.0	6.1
B14	0−2	1846.7	51.2	2436.0	548.8	1207.0	
B16	0−2	972.9	39.0	1636.5	438.8	1515.0	7.1
Mount Haggin							
C1	0−2	133.6	3.6	196.6	96.3	122.9	4.8
C2	0−2	317.9	6.3	370.9	142.5	185.4	
C3	0−2	224.2	8.6	374.8	179.0	379.3	7.9
C4	0−2	238.5	2.3	139.1	88.2	76.6	
C5	0−2	178.2	3.4	185.4	94.1	87.8	5.3
C6	0−2	299.6	8.4	549.0	188.4	236.7	5.1
C7	0−2	107.6	3.6	185.3	78.1	123.1	5.5
C8	0−2	237.1	6.7	289.2	180.0	168.8	
C9	0−2	630.0	10.6	678.7	229.2	318.7	4.9
C10	0−2	181.6	4.5	261.6	125.7	126.4	
C11	0−2	215.6	5.9	224.9	90.4	158.6	
C12	0−2	336.9	12.2	371.5	176.7	304.6	5.3
C13	0−2	471.9	12.7	519.2	204.4	255.4	
C14	0−2	247.4	10.8	395.8	179.4	263.1	5.1
C15	0−2	576.3	13.1	588.6	223.1	340.4	

Sample	Depth (in)	As (ppm)	Cd (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	pH
Stucky Ridge Controls							
AA2	0–2	47.2	3.4	220.4	112.7	147.5	
AA3	0–2	82.7	4.0	172.2	81.8	182.6	6.1
AA6	0–2	82.1	3.8	215.4	101.8	138.7	
AA8	0–2	59.2	4.1	172.3	89.7	164.6	
AA10	0–2	119.6	2.2	135.5	60.8	121.0	
Smelter Hill Controls							
BB2	0–2	47.3	2.0	126.2	52.1	122.4	6.0
BB3,15	0–2	88.3	4.0	236.5	77.5	196.3	5.9
BB5	0–2	103.6	1.7	96.4	41.0	80.2	
BB7	0–2	132.3	3.6	146.8	57.3	162.7	
BB9	0–2	96.9	2.6	126.7	51.5	176.1	6.2
BB11	0–2	86.3	4.3	189.0	88.0	160.2	
BB13	0–2	98.2	1.9	107.9	54.1	104.2	5.6
BB16	0–2	74.4	2.8	117.8	45.5	125.6	
Mount Haggin Controls							
CC1	0–2	107.6	1.8	88.0	36.5	96.9	
CC3	0–2	106.6	5.1	186.6	94.1	165.4	5.6
CC5	0–2	53.0	2.3	104.7	49.8	110.8	5.6
CC7	0–2	65.7	4.1	201.5	119.7	141.3	
CC9	0–2	110.8	1.3	58.6	31.1	78.4	
CC12	0–2	115.5	1.7	85.1	32.0	93.4	
CC14	0–2	136.4	2.2	106.6	32.6	124.4	5.2
Stucky Ridge							
A3	0–6	188.9	3.2	1029.6	64.7	253.7	8.4
A6	0–6	184.9	2.2	935.1	72.1	191.4	5.6
A10	0–6	385.6	4.0	1272.4	130.3	351.2	5.0
Smelter Hill							
B3	0–6	114.0	4.0	395.4	76.6	240.5	7.5
B5	0–6	134.2	7.1	542.3	139.4	278.2	6.9
B11	0–6	578.2	16.4	865.7	190.3	429.8	5.4
B13	0–6	539.0	16.4	576.4	248.0	477.2	6.1
B16	0–6	642.5	21.8	972.9	306.3	792.6	7.3
Mount Haggin							
C1	0–6	93.5	3.1	118.4	51.0	119.9	5.3
C7	0–6	133.1	2.8	198.5	75.3	103.3	5.5
C9	0–6	378.0	10.0	493.9	169.7	283.0	5.1
C14	0–6	172.5	5.5	194.5	70.0	212.9	5.7
Smelter Hill Controls							
BB3,15	0–6	84.3	2.5	125.5	49.4	128.4	5.7
BB13	0–6	45.2	1.2	72.0	32.8	83.8	6.0
Mount Haggin Controls							
CC3	0–6	70.2	1.4	89.4	39.9	93.8	5.7
CC5	0–6	40.7	0.7	41.6	21.7	68.8	5.7

Sample	Depth (in)	As (ppm)	Cd (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	pH
Reach 1	Silver Bow Creek						
R1	0–2	414.1	4.3	485.5	492.4	1500.9	
R2	0–2	274.3	12.2	615.2	392.0	3702.0	
R3	0–2	509.0	17.8	4014.0	780.2	5108.0	
R4	0–2	295.0	4.7	927.8	468.0	1559.9	3.5
R4	0–6	382.6	5.8	995.0	615.8	1988.8	3.6
R5	0–2	418.9	10.3	1645.7	885.8	3568.0	
R6	0–2	336.4	3.7	478.0	528.3	1460.9	
Reach 2	Silver Bow Creek						
R7	0–2	186.7	2.4	407.5	337.6	906.4	
R8	0–2	163.6	1.7	407.6	314.2	720.5	3.8
R8	0–6	172.1	1.6	345.9	285.4	754.4	4.0
R9	0–2	409.0	7.4	1414.5	631.5	2152.0	
R10	0–2	425.6	6.3	1269.6	836.6	2076.0	
R11	0–2	169.6	4.0	738.2	307.3	1160.8	
R12	0–2	230.1	8.3	1195.3	437.8	2010.0	
Reach 3	Clark Fork River						
R13	0–2	334.7	8.5	3644.0	236.8	1607.2	5.4
R13	0–6	268.1	5.8	1887.4	200.8	1152.8	6.2
R14	0–2	327.9	4.9	1723.4	281.1	1312.6	4.5
R14	0–6	275.1	3.5	1183.2	240.8	1033.5	4.4
R15	0–2	476.4	3.5	1928.9	360.0	1267.6	
R16	0–2	291.8	1.1	566.5	245.8	549.5	
R18	0–2	525.5	5.3	2200.0	339.1	1414.7	
Control Reach 1		Divide Creek					
RR1	0–2	10.0	0.7	28.7	19.6	69.7	
RR2	0–2	17.5	0.8	56.4	22.0	75.9	
RR3	0–2	18.4	1.0	31.0	23.7	87.1	
RR4	0–2	19.3	0.5	33.9	17.3	67.3	
RR5	0–2	23.1	5.8	55.0	40.0	136.0	
RR6	0–2	76.4	1.1	55.4	34.5	117.6	
Control Reach 2		Little Blackfoot					
RR7,13	0–2	22.9	0.4	20.9	31.1	100.6	7.5
RR7	0–6	25.9	0.5	16.8	34.2	135.0	
RR8	0–2	44.1	0.6	25.1	43.2	117.4	
RR9	0–2	33.9	1.4	43.6	100.1	169.7	
RR10	0–2	42.5	1.0	32.4	52.0	151.4	
RR11	0–2	12.5	0.5	14.3	28.2	70.2	
RR12	0–2	12.9	0.3	13.8	19.1	62.4	
Control Reach 3		Flint Creek					
RR13	0–6	9.4	1.2	17.0	20.3	55.2	
RR14	0–2	92.6	1.4	50.5	139.3	361.0	
RR15	0–2	112.0	1.7	72.8	176.1	468.0	
RR16	0–2	36.6	0.6	33.2	51.2	194.4	
RR17	0–2	51.4	0.6	28.2	66.5	201.3	
RR18	0–2	145.4	1.9	64.6	205.7	523.8	
Opportunity Ponds							
OP1	0–2	1398.1	68.1	9980.0	722.6	2676.0	
OP2	0–2	204.2	2.1	728.2	460.9	475.7	
OP3	0–2	18.5	0.7	301.6	54.2	68.0	3.7
OP4	0–2	237.7	0.8	420.0	213.4	204.2	
OP5	0–2	123.5	1.9	337.0	58.4	267.7	

APPENDIX B

Evaluation of Phytotoxicity of Upland and Riparian Soils, Clark Fork River Basin, Montana

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EXECUTIVE SUMMARY

Phytotoxicity tests were conducted as part of the Natural Resource Damage Assessment of the upper Clark Fork River Basin, Montana, to assess injury to upland and riparian soils, vegetation, and wildlife. Field observations of impacted areas in the Anaconda-Butte area and laboratory phytotoxicity tests on soils from the area were completed during the summer and early fall of 1992. Sampling sites were coordinated with other work performed to assess injury to terrestrial resources that is reported separately in the Terrestrial Injury Assessment Report. Standard laboratory tests were used to evaluate phytotoxicity of site soils to support the determination of injury to soils and vegetation.

The results of the laboratory phytotoxicity studies support the conclusions that:

- Soils from both riparian impact areas (Silver Bow Creek and the Clark Fork River floodplains, and the Opportunity Ponds) and upland impact areas (Stucky Ridge, Smelter Hill, and Mt. Haggin) contain concentrations of hazardous substances in sufficient concentration to cause a phytotoxic response in vegetation.

- The degree of phytotoxic response, defined by reductions in eighteen species-endpoint criteria, was correlated with total and "bioavailable" concentrations of hazardous substances in the soil.

- The observed patterns of plant response are consistent with theoretical expectations as suggested by existing literature and field observations.

Riparian impact areas (Silver Bow Creek and the Clark Fork River floodplains, and the Opportunity Ponds) were found to be severely toxic to standard test plants, alfalfa, lettuce, and wheat. The riparian soils were also severely toxic to hybrid poplar plants that were used to represent resident, native cottonwood and willow species. Soil from all three upland impact areas near Anaconda (Stucky Ridge, Smelter Hill, Mt. Haggin) were phytotoxic. Eighteen of the 20 (90%) soil samples collected from the impact areas were phytotoxic. Hazardous substance concentrations (especially, arsenic, copper, and zinc) were correlated with phytotoxic responses. High pH soils were found to be less phytotoxic; elevated pH has been shown in the literature to reduce the phytotoxicity of metals. Overall, the results of the phytotoxicity studies confirm that hazardous substances have injured upland and riparian soils and vegetation resources.

1.0 BACKGROUND

This report addresses the assessment of injury to soil and vegetation resources resulting from the release of hazardous substances by mining and mineral-processing operations in Butte and

Anaconda. Soil sampling and laboratory analyses were performed to provide quantitative information on the extent and concentration of hazardous substances in exposed upland and riparian soils and matching control sites (see Appendix A). Phytotoxicity studies were performed to assess injury to soils and vegetation based on the response of plants grown in soils impacted by hazardous substances.

2.0 OBJECTIVES

Field and laboratory work were designed to determine whether current soil conditions adversely limit the ability of plants to establish, grow, and provide habitat suitable for wildlife. Phytotoxicity tests were conducted to quantify injury to soils of two main areas identified as potentially injured: (1) barren streamside tailings deposits (slickens) in riparian zones of Silver Bow Creek and the Clark Fork River; and (2) upland sites that previously supported forest and grassland habitat. Control sites were sampled to represent baseline conditions (i.e., the conditions that would occur in the absence of the releases of hazardous substances).

3.0 METHODS

3.1 LABORATORY METHODS

Soil collection methods and chemical analyses are described in Appendix A. Splits of 42 soil samples were transported to the ep&t laboratory in Corvallis, Oregon for laboratory germination and growth tests. Two types of tests, screening and extended, were performed (Table 3-1).

Screening tests were performed to examine the performance of standard laboratory test species (alfalfa, lettuce, and wheat) exposed to 100% impact soil or control soil for two weeks. Extended tests examined the performance of hybrid poplar (a surrogate species representative of native southwestern Montana riparian species) exposed to site soil for four weeks.[1] Standard Operating Procedures consistent with the ASTM protocol for early

[1] Initial plans specified in the State of Montana's Natural Resource Damage Assessment Plan-Part II included extended tests of upland soil samples with Douglas fir seedlings. The extended tests with Douglas fir were attempted; however, no useable results were obtained. Growth of Douglas fir plants in all treatments including the control soils was minimal during the four-week test period. Sporadic development of new shoots occurred, but no detectable pattern was noted. Root growth was minimal and sporadic across treatments. The logistics of obtaining site soils pushed the earliest start date to the last week of July 1992. The Douglas fir seedlings appeared to have completed their annual growth before the tests were initiated. The limited growth that did occur was insufficient to evaluate growth. Also, since the plants were relatively inactive in terms of growth, it is unlikely that toxicity symptoms would be manifested during the four-week exposure period available for this study. Consequently, this extended test was aborted.

Table 3-1
Comparison of Screening and Extended Phytotoxicity Tests

Test Element	Screening	Extended
Plant species	Alfalfa, lettuce, wheat	Hybrid poplar
Starting material	Seeds (20 per replicate)	Stem cuttings (1 per replicate)
Soil	100% impact soil 100% control soil	100% impact soil 100% control soil 50% impact: 50% control soil
Replicates	5 per species in impact soil 5 per species in control soil	5 in impact soil 5 in control soil 5 in 50:50 mixture
Duration of test	14 days	28 days
Endpoints	Germination/emergence (%) Shoot growth (height, mm; oven dry weight, g) Root growth (maximum length, mm; oven dry weight, g)	Survival Shoot growth (height, mm; oven dry weight, g) Root growth (maximum length, mm; oven dry weight, g)

seedling growth studies (ASTM, 1994[2]) were adapted to compare germination and seedling performance of the standard test species, and root and shoot growth performance of the hybrid poplar, in impact and control soils.

For both screening and extended tests, the growth chamber was illuminated with fluorescent and incandescent light on a 16:8 h light:dark photoperiod. Measured light intensity (mean $\pm$ standard deviation) was 93 ± 14 $\mu E\ m^{-2}\ s^{-1}$ photosynthetically active radiation (PAR). Day temperature was maintained at 22.3 ± 2.0°C; night temperature was 20.9 ± 2.7°C. Relative humidity was 53.5 ± 7.5% in daytime and 60.9 ± 12.5% during nighttime. Soils were watered with bottled distilled water to achieve appropriate water-holding capacity at the start of the test. Throughout the duration of the test, water was added twice daily or as needed to bring soils to appropriate water-holding capacity.

[2] At the time that the laboratory tests were performed, this standard was available as a working draft. The essential features of the test incorporated the methods outlined in Green et al., 1989 and Gorsuch et al., 1990.

3.1.1 Extended Tests

Extended tests were designed to evaluate the phytotoxicity of riparian soils to hybrid poplar, a representative surrogate for cottonwood and willow. Dormant hybrid poplar cuttings were obtained from Dr. Paul Heilman, Washington State University Research Station, Puyallup, Washington. One week before test initiation, the cuttings were removed from the refrigerator, cut into approximately 15-cm lengths with pruning shears, and placed in water to a depth of 5-8 cm. After one week, plants that had new roots and shoots were planted in 4 inch by 6 inch plastic (PVC) cylinders containing either impact or control soil.

Four soil samples collected from slickens along Silver Bow Creek and the Clark Fork River were used for the extended impact tests (R-04, R-08, R-13, and R-14; Table 3-2). Five hybrid poplar stems were planted in each of the four impact soil samples, for an initial total of 20 test plants. A composite of soil collected from the Little Blackfoot River and Flint Creek was used as a control soil for the extended tests (see Appendix A). Five hybrid poplar stems were planted in control soil. An additional 20 hybrid poplar stems were planted in a mixed soil consisting of 50% impact soil and 50% control soil.

Throughout the tests, routine observations were recorded to note death or overt symptoms of stress. At the conclusion of four weeks, plants were harvested and measured for shoot length, maximum root length, and oven dry weights of shoots and of roots.

3.1.2 Screening Tests

Soils collected from the 0-2 inch layer were used in upland and riparian screening tests.

The screening tests were designed to evaluate the phytotoxicity of soils to standard laboratory test species. Approximately 100 g of soil was placed in 4 inch by 4 inch x 0.75 inch plastic trays. Seeds of alfalfa, lettuce, and wheat were placed in the soil to a depth sufficient to cover the seeds. Five replicates per species of 100% impact soil and 100% control soil were used.

Growth in 20 impact soil samples from three upland impact areas (Stucky Ridge, Smelter Hill, and Mount Haggin) was compared to growth in nine control soils (Table 3-2). Growth performance in four impact soils from riparian areas (Silver Bow Creek and the Clark Fork River floodplains, and the Opportunity Ponds) was compared to growth in one control soil composited from two control sites (see Appendix A).

At the end of one week, the number of germinated seeds was counted. The mean emergence of five trials (20 seeds each) per species was compared to the emergence determined in the control samples. Individuals that germinated were observed over a 14-day post-germination

Table 3-2
Sample Identification for Screening and Extended Phytotoxicity Tests of Upland and Riparian Impact and Control Soils

Soil Type and Area	Screening Tests (0-2 inch depth)	Extended Tests (0-6 inch depth)
Upland impact areas		
▸ Stucky Ridge	A-02 A-03 A-06 A-08 A-10	
▸ Smelter Hill	B-02 B-03 B-04 B-05 B-09 B-11 B-13 B-16	
▸ Mount Haggin	C-01 C-03 C-05 C-07 C-09 C-12 C-14	
Upland control areas (German Gulch)	AA-03 BB-02 BB-03,15 BB-09 BB-13 CC-01 CC-03 CC-05 CC-14	
Riparian impact soils	R-04 R-08 R-13 R-14 OP-2	R-04 R-08 R-13 R-14 OP-2
Riparian control soils	RR-07/13 (composite)	RR-07/13 (composite)

period and, upon harvesting, were measured to determine whether impact and control plants differed in shoot length, maximum root length, shoot mass, root mass, and overall mass.

Performance of the standard test species (alfalfa, lettuce, and wheat) in nontoxic laboratory growth medium was evaluated for quality control. The results are presented in Table 3-3.

Mean germination rates ranged from 89% for lettuce to 92% for alfalfa and wheat seeds. The data indicate that the seeds used and the conditions maintained in the laboratory were proper for the conduct of the tests.

Table 3-3
Germination Success of Alfalfa, Lettuce, and Wheat in Control Soils
Based on Five Replicates of 20 Seeds Each Over a Two Week Trial

Species	Germinated (mean #)	Standard Deviation	Standard Error	Minimum # Germinated	Maximum # Germinated	% Germination
Alfalfa	18.4	1.1	0.5	17	20	92
Lettuce	17.8	1.9	0.9	15	20	89
Wheat	18.4	0.5	0.2	18	19	92

3.2 SPECIES-ENDPOINT CRITERIA

The following endpoints were measured to evaluate phytotoxicity:

1. Seed germination (for screening tests only — number of seedlings emerged/20 seeds; 5 replicates of 20 seeds each, for each species).

2. Shoot height (mm, for each surviving plant; mean of plants measured).

3. Shoot mass (g oven dry weight for each plant; mean of plants measured).

4. Maximum root length (mm, for each surviving plant; mean of plants measured).

5. Root mass (g oven dry weight for each surviving plant; mean of plants measured).

6. Total plant mass (g oven dry weight for each surviving plant; mean of plants measured).

A total of 18 species-endpoint measures were tabulated for all soils in which seeds germinated (six endpoints, three species). Plants that did not germinate were (conservatively) not considered in the subsequent analyses of growth.

In addition, plant survival — the number of plants that survived the full 28-day exposure period — was calculated for extended testing using hybrid poplars.

3.3 STATISTICAL METHODS

3.3.1 Extended Tests

Shoot height, root length, shoot mass, and root mass of hybrid poplar impact samples were measured on all surviving plants. Measurements at the end of the test included pre-test growth (not including the "parent cutting") plus additional growth (living and dead) during the 28 days of the test. Pre-test growth was estimated as the mean growth (shoot and root) of five plants each in two of the impact soils that died soon after exposure to the soils (Section 4.1). The estimate of pre-test growth was subtracted from post-test measurements to derive an estimate for growth during the 28-day exposure period. Mean values for the endpoints (shoot height, root length, shoot mass, and root mass) for each impact soil were compared to the control plants using a t-test. All results are reported at the α = 5% level.

3.3.2 Screening Tests

Each species endpoint per impact sample was compared to the corresponding control mean using a t-test. For example, in a given impact soil, the shoot length of alfalfa (mean of five trials, 20 seeds per trial) was compared to the shoot length of alfalfa in control soil (mean of alfalfa plants in control soils). Variance for both impact samples and control samples was assumed to be the pooled variance over the impact area and the control area (upland and riparian variance were calculated independently). The riparian impact samples were tested under two different assumptions of variance because the control for the riparian impact samples consisted of a single soil sample composited from two sample sites. The first assumption was that the variance of the riparian control area was equal to the variance of the riparian impact area. The second assumption was that the variance of the riparian control area was equal to the variance of the upland control area (reported as "not equal to the riparian impact area"). The germination percentages were transformed using the $\arcsin\sqrt{p}$ transformation (Steel and Torrie, 1980) before running t-tests. Results are reported at the α = 5% level. Results of both series of tests are presented in Tables A-6 through A-10 in Attachment A.

3.4 DEFINITION OF PHYTOTOXICITY

Phytotoxicity was confirmed if a statistically significant reduction occurred in one of the species endpoints relative to the control. The *degree* of phytotoxicity was also quantified based on:

- The extent of the difference between impact and controls
- The number of toxicity endpoints exhibiting a phytotoxic response
- The number of species exhibiting a phytotoxic response.

In other words, soils that were found to cause large decreases in several toxicity endpoints for more than one test species were deemed more phytotoxic.

Species-endpoint toxicity scores were assigned based on the magnitude of the difference between impact and controls. If a test yielded a p-value greater than 0.05 (i.e., no significant difference between test and control), the value of the toxicity score assigned to that response variable for the given species was 0.0 (null-hypothesis accepted). If the p-value for the test of the above hypothesis was less than or equal to 0.05 (i.e., significant difference between test and control), then:

- If the difference between 0.25 times the control mean and the impact sample value for an endpoint was greater than or equal to 0, the value of the toxicity score assigned to that variable for the given species was 4.0.

- If the difference between 0.50 times the control mean and the impact sample value for an endpoint was greater than or equal to 0, the value of the toxicity score assigned to that variable for the given species was 2.0.

- If the difference between 0.75 times the control mean and the sample value for an endpoint was greater than or equal to 0, the value of the toxicity score assigned to that variable for the given species was 1.0.

- Otherwise, the value of the toxicity score assigned to that variable for the given species was 0.5.

Table 3-4 presents the evaluation criteria and toxicity scores assigned to each test based on the degree of separation from the control.

Results of the statistical tests and the toxicity scores were summarized (Table 3-5). The sum of the toxicity scores for each species endpoint over all species endpoints per site provided an overall site toxicity index. The theoretical range for scores using 18 species-endpoint measures is 0 (non-toxic) samples to 72 (extremely toxic) (Table 3-6).[3]

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[3] The use of multiple toxicity assays and endpoints was forwarded in Porcella, 1983. Subsequently, various scoring protocols have been used to facilitate analysis of multiple endpoints. Examples of scoring protocols may be found in site assessment reports prepared by the U.S. EPA ERL-Corvallis for the United Chrome, Drake Chemical, Douglassville, and MacLaren Superfund sites (Green, 1989; NSI Technological Services, 1988; Linder, 1988a,b), and by the U.S. Army for the Joliet Army Ammunition Plant (Phillips et al., 1994).

Table 3-4
Evaluation Criteria and Phytotoxicity Scores Used to Characterize Species-Endpoint Responses

Degree of Separation from Controls	Toxicity Score
Not significantly less than controls*	0.0
Significantly less than controls and > 75% of controls	0.5
Significantly less than controls and > 50 % to ≤ 75% of controls	1.0
Significantly less than controls and > 25 % to ≤ 50% of controls	2.0
Significantly less than controls and ≤ 25% of controls	4.0

* Statistical difference is defined to be the 5% level ($\alpha = 0.05$) for one-tailed tests.

Table 3-5
Sample Tabulation of Species-Endpoint Toxicity Scores for a Single Sample Site (example data from site A-10)

Species	Endpoint	Toxicity Score
Alfalfa	Germination	2
	Shoot height	4
	Root length	4
	Shoot mass	4
	Root mass	4
	Total plant mass	4
Lettuce	Germination	0
	Shoot height	4
	Root length	4
	Shoot mass	0
	Root mass	0
	Total plant mass	0
Wheat	Germination	0
	Shoot height	4
	Root length	4
	Shoot mass	2
	Root mass	2
	Total plant mass	2
Site Sample Score		**44**

Table 3-6 Definition of Degree of Phytotoxicity Based on Site Toxicity Index	
Phytotoxicity Category	**Site Toxicity Index Categories**
Nontoxic	No significant response (phytotoxicity score < 0.5)
Mildly toxic	0.5 to 9
Moderately toxic	9.1 to 18
Highly toxic	18.1 to 36
Severely toxic	36.1 to 72

4.0 RESULTS

4.1 EXTENDED TESTS — RIPARIAN SOILS

Initiation of shoots and roots on the dormant hybrid poplar stems planted in riparian control and impact soils occurred over the course of several days. At the start of the phytotoxicity test, some plants had well established roots and new shoots (i.e., 3-4 days new growth) while others had less well developed roots and shoots (i.e., 1-2 days). To address these developmental differences, plants were assigned randomly to impact and control soil treatments.

Ten of the initial 20 poplars in 100% impact soil (five each from sites R-04 and R-14) wilted and died within 24 hours of transplanting; two of the five poplars in control soil died. As a precaution against misinterpretation of transplanting stress versus toxicity, these three treatments were repeated (five more poplars were planted in each of R-04, R-14, and control soil). Again, all 10 impact soil plants in the repeat trials (all five in each of R-04 and R-14 soils) died. All five plants in the repeat control soil test remained normal in appearance. No mortality occurred during the remainder of the test in either control soils or 50% mixed soils, but all five plants in impact soil R-08 were dead at the conclusion of the 4-week test (Table 4-1). Root conditions of the plants were noted at the conclusion of the 4-week test. Figures 4-1 to 4-5 photo-document the differences between control and site soil treatments.

Mean values of shoot height, root length, shoot mass, and root mass of hybrid poplar impact samples calculated over the surviving replicates for each soil were compared to the control sample results using a t-test. Mean values for each variable (impact and control) are presented in Table 4-2 and illustrated in Figures 4-6 to 4-11. Shoot height, root length, shoot mass, and root mass for all 100% impact soil samples (R-04, R-08, R-13, and R-14) were significantly less than corresponding values determined for the control sample (RR-07). Values for shoot height, root length, shoot mass, and root mass in mixed soils (50% impact soil + 50% control soil) were not statistically different from the control values for any of the sites tested.

Figure 4-1. **Hybrid Poplar Plants after 28 Days Exposure to Riparian Soil.** Plants in the center group were exposed to riparian control soil Plants on the left of the photograph were exposed to R-04 site soil Plants on the right of the photograph were in R-14 site soil

Figure 4-2. Representative Hybrid Poplar Plants Excavated from Riparian Soil after 28 Days Exposure. The plant on the left was exposed to riparian control soil. The plant on the right was exposed to R-04 site soil.

Figure 4-3. Hybrid Poplar Plants Excavated from Riparian Control Soil after 28 Days Exposure. The five plants are replicates from the repeated test.

Figure 4-4a. Hybrid Poplar Plants Excavated from Riparian Site Soil (R-14) after 28 Days Exposure. All new shoot growth that formed before the start of the test died within the first few days (1-3 days) exposure. Roots were dead at the termination of the test.

Figure 4-4b. Hybrid Poplar Plants Excavated from Riparian Site Soil (R-04) after 28 Days Exposure. All new shoot growth formed before the start of the test died within the first few days (1-3 days) exposure. Roots were dead at the termination of the test

Figure 4-5a. Hybrid Poplar Plants Excavated from Riparian Site Soil (R-13) after 28 Days Exposure. Note the limited quantity of roots compared to the plants from control soil (shown in Figure 4-3).

Figure 4-5b. Hybrid Poplar Plants Excavated from Riparian Site Soil (R-08) after 28 Days Exposure. Note the limited quantity of roots compared to the plants from control soil (shown in Figure 4-3)

Table 4-1
Hybrid Poplar Mortality in Riparian Impact Soils

Soil	Number of Replicates	Dead within 72 Hours		Dead after 28 Days	
		Number	Percentage	Number	Percentage
Control (RR-07)					
First test	5	2	40	2	40
Repeat test	5	0	0	0	0
100% impact soil					
R-04 First test	5	5	100	5	100
R-04 Repeat test	5	5	100	5	100
R-08	5	0	0	5	100
R-13	5	0	0	2	40
R-14 First test	5	5	100	5	100
R-14 Repeat test	5	5	100	5	100
50% mixed soil					
R-04:RR-07	5	0	0	0	0
R-08:RR-07	5	0	0	0	0
R-13:RR-07	5	0	0	0	0
R-14:RR-07	5	0	0	0	0

Table 4-2
Shoot Height (mm), Root Length (mm), and Mass (g) of Hybrid Poplar Shoots and Roots Measured after 28 Days Exposure to Riparian Control or Impact Soil

Sample	RR-07 (Control)	R-04	R-08	R-13	R-14
Shoot height					
100% soil	192±5 (148±52)	56±15* (49±18*)	95±33*	90±29*	61±13* (71±21)*
50% mix soil	NA	216±50	164±74	226±31	129±74
Root length					
100% soil	181±40 (140±41)	42±35* (32±13*)	39±NC*	21±19*	20±10* 2±5*
50% mix soil	NA	199±27	184±16	160±5	151±28
Shoot mass					
100% soil	1.150±0.182 (0.775±0.250)	0.195±0.540* 0.129±0.031*	0.195±0.080*	0.251±0.073*	0.150±0.09* 0.166±0.024*
50% mix soil	NA	1.204±0.366	0.779±0.388	1.012±0.245	0.681±0.480
Root mass					
100% soil	0.751±0.316 (0.128±0.042)	0.019±0.017* 0.020±0.013*	0.013±NC*	0.012±0.016*	0.040±0.041* 0.002±NC*
50% mix soil	NA	1.149±0.888	0.596±0.720	0.632±0.222	0.712±0.634

Values are mean ± standard deviation. Values in parentheses are results of repeat tests.
* indicates growth significantly less than the control at $\alpha = 0.05$.
NA = not applicable; NC = not possible to calculate.

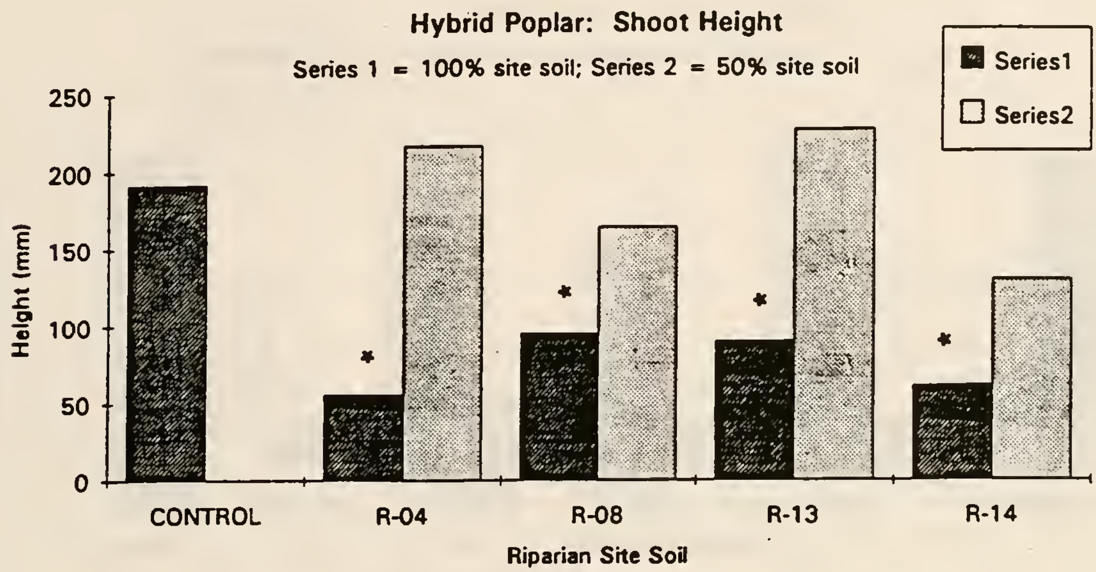

Figure 4-6. Hybrid Poplar Shoot Height Following 28 Days Exposure to Riparian Soils. Sample RR-07 was the control soil. Values from repeat tests not shown on graph. * = significantly less than control ($p < 0.05$).

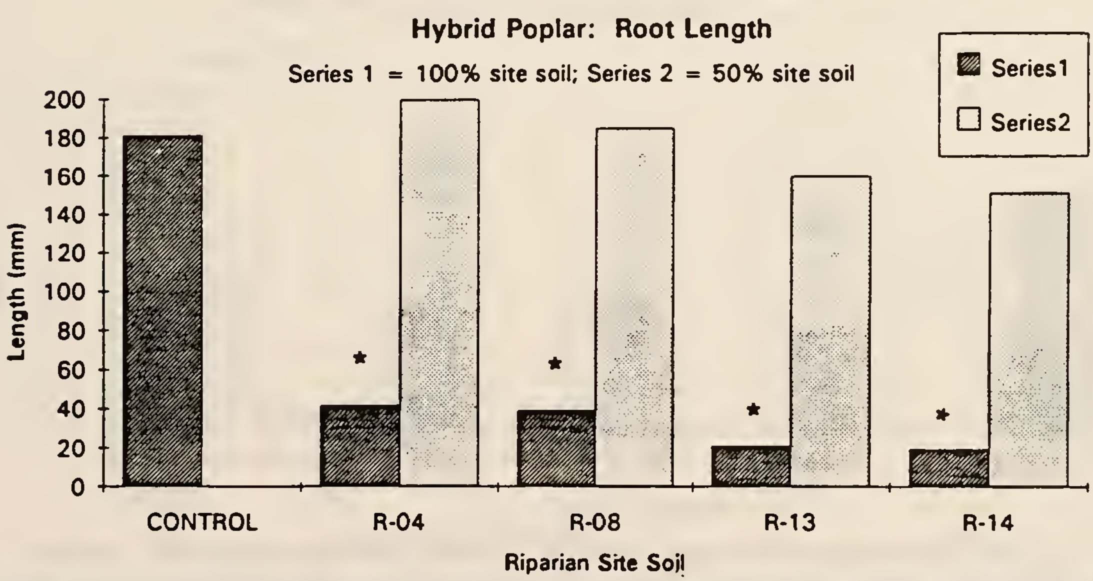

Figure 4-7. Hybrid Poplar Root Length Following 28 Days Exposure to Riparian Soils. Sample RR-07 was the control soil. Values from repeat tests not shown on graph. * = significantly less than control ($p < 0.05$).

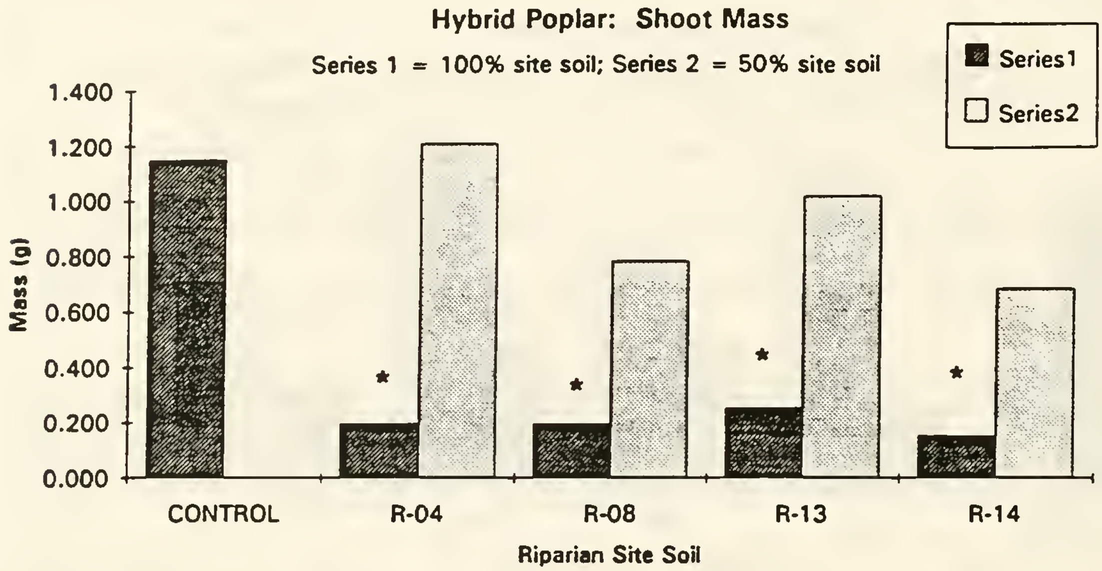

Figure 4-8. Hybrid Poplar Shoot Following 28 Days Exposure to Riparian Soils. Sample RR-07 was the control soil. Values from repeat tests not shown on graph. The values (mm) for shoot height are listed in Table 4-6.
* = significantly less than control ($p < 0.05$).

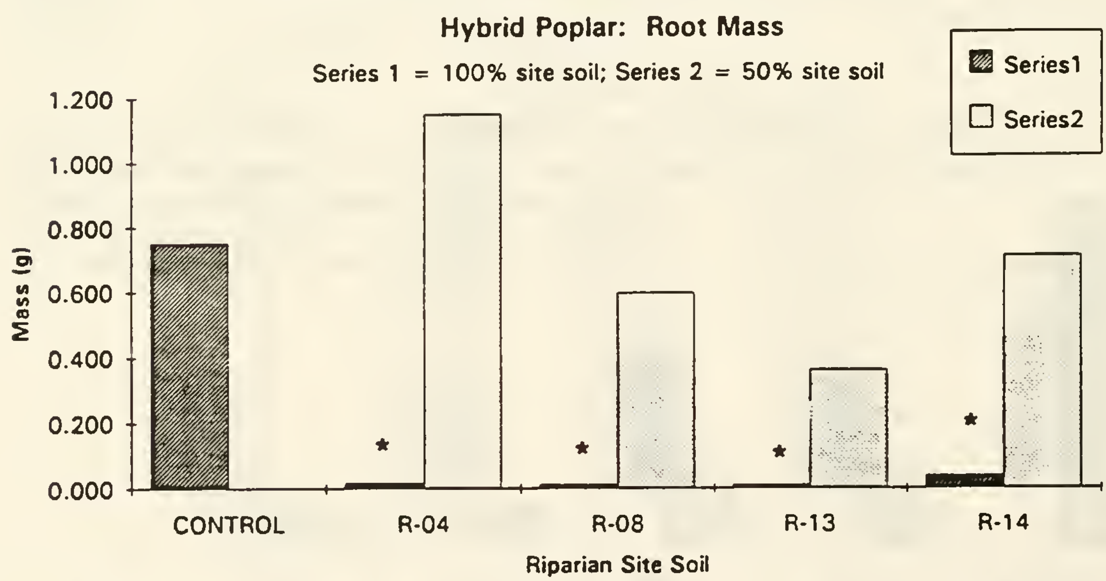

Figure 4-9. Hybrid Root Mass Following 28 Days Exposure to Riparian Soils. Sample RR-07 was the control soil. Values from repeat tests not shown on graph. The values for root length are listed in Table 4-6.
* = significantly less than control ($p < 0.05$).

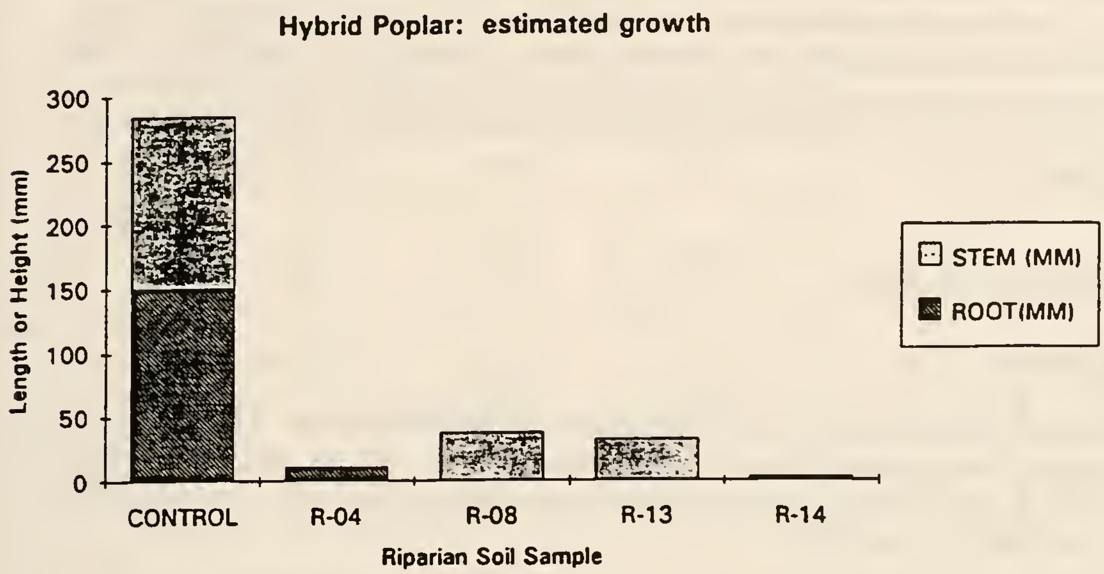

Figure 4-10. Estimated Growth (shoot length and root length) of Hybrid Poplars During the 28-Day Exposure to Riparian Soils. Sample RR-07 was the control. Values from repeat tests not shown on graph.

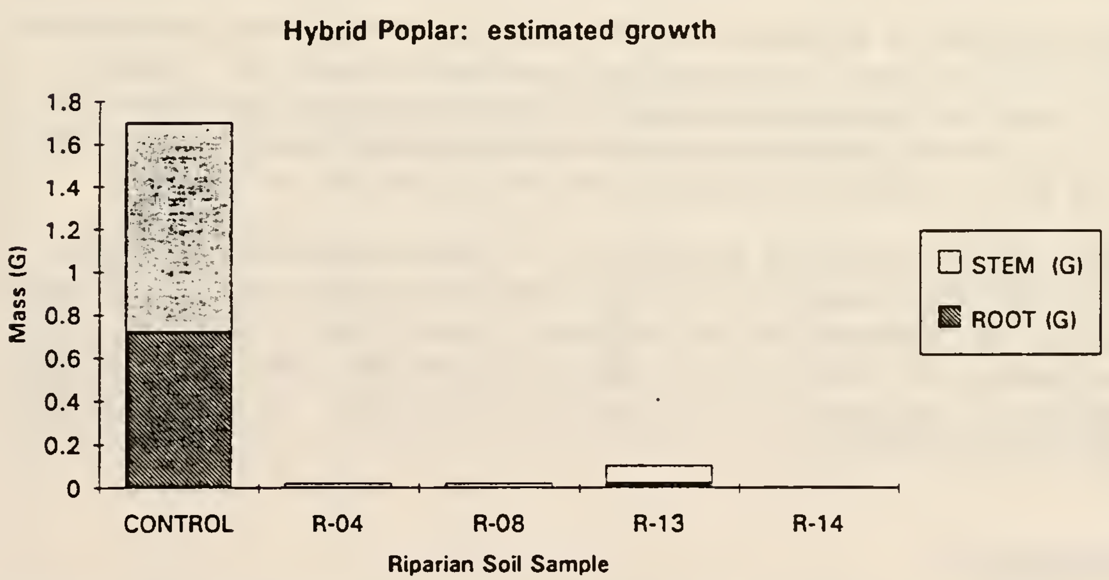

Figure 4-11. Estimated Growth (shoot and root mass) of Hybrid Poplars During the 28-Day Exposure to Riparian Soils. Sample RR-07 was the control. Values from repeat tests not shown on graph.

The plants in soils from sites R-04 and R-14 died soon after exposure. Using the growth measurements from these plants as an estimator of the pre-test growth, adjustments were made to illustrate the growth of hybrid poplars during the 28-day exposure period. These adjusted data are presented in Table 4-3 and in Figures 4-10 and 4-11. The values in Table 4-3 were converted to percentage growth inhibition relative to control plants (Table 4-4). Except for a small increment of stem height growth in R-08 and R-13 soils, inhibition was essentially complete.

4.2 SCREENING TESTS

4.2.1 Germination

The first endpoint of the screening level tests was germination/emergence. The number of seedlings that had emerged above the soil surface was recorded after one week and at the end of the two-week period. The total number of plants that had emerged at the end of the two-week period was used for analysis.

The range of emergence values for alfalfa in the riparian impact soils was 0% in R-04 and R-14 impact soils to 100% in RR-7 control soil. The lettuce emergence ranged from 0% in upland impact site B-11 soil and riparian impact sites R-04 and R-14 soil, to 90% for upland impact site C-5 soil. The range of emergence values for wheat was 0% in riparian impact soils R-4 and R-14 to 95% in upland impact soil A-08.

For each riparian impact site, the mean emergence of five trials (20 seeds each) per species was compared to the emergence determined in the control sample using a t-test. Alfalfa emergence in impact soils was significantly less ($p < 0.05$) than in control soils for sites R-04, R-08, and R-14 (Table 4-5). Wheat and lettuce emergence were significantly less ($p < 0.05$) in impact soils than in controls for all impact samples (R-04, R-08, R-13, and R-14).

For each upland impact site, the mean emergence of five trials (20 seeds each) per species was compared to the mean emergence per species over all upland control trials using a t-test. Alfalfa emergence was statistically less ($p < 0.05$) than controls for sites A-10 (Stucky Ridge), B-04 (Smelter Hill), and C-05, C-07, and C-09 (Smelter Hill). Emergence of alfalfa on the remaining sites, and emergence of lettuce and wheat on all sites, was not significantly different from controls (Table 4-5).

4.2.2 Height/Length

The height of the shoot and maximum length of roots of each germinated plant was recorded to the nearest millimeter at the conclusion of the 14-day exposure period. The values for shoot height and root length are listed in Table 4-6.

Table 4-3
Estimated 28-Day Growth of Hybrid Poplar Shoots and Roots Measured after 28 Days Exposure to Riparian Control or Impact Soil

Sample	RR-07 (Control)	R-04	R-08	R-13	R-14
Shoot height					
100% soil	134±5	0±15	37±33	32±29	3±13
50% mix soil	NA	158±50	106±74	168±31	71±74
Root length					
100% soil	150±40	11±35	0±NC	0±18	0±10
50% mix soil	NA	168±27	153±16	129±5	120±28
Shoot mass					
100% soil	0.978±0.182	0.023±0.054	0.023±0.080	0.079±0.073	0.000±0.090
50% mix soil	NA	1.032±0.366	0.607±0.388	0.840±0.245	0.509±0.480
Root mass					
100% soil	0.721±0.316	0.000±0.017	0.000±NC	0.025±0.010	0.002±0.040
50% mix soil	NA	1.119±0.720	0.566±0.720	0.332±0.222	0.682±0.634

Values are mean ± standard deviation.
NA = not applicable; NC = not possible to calculate.

Table 4-4
Percentage Inhibition of Hybrid Poplar Growth
Estimated 28-Day Growth of Plants in Impact Soil Relative to Estimated 28-Day Growth of Plants in Control Soil

Endpoint	R-04	R-08	R-13	R-14
Shoot height	100	72	77	98
Root length	93	100	100	100
Shoot mass	98	98	92	100
Root mass	100	100	97	100

Table 4-5
Germination/Seedling Emergence of Alfalfa, Lettuce, and Wheat

Sample	Alfalfa	Lettuce	Wheat
Upland controls			
AA-3	18±2	2±2	17±3
BB-2	18±2	9±6	18±1
BB-9	19±1	9±8	17±5
BB-13	19±1	9±6	16±1
BB-3,15	17±2	8±3	15±3
CC-3	18±1	4±5	19±1
CC-5	18±1	7±2	19±1
CC-14	18±2	0	19±1
Upland impact			
Stucky Ridge			
A-2	16±4	13±8	19±1
A-3	11±3	1±2	16±3
A-6	10±3	6±5	18±2
A-8	19±1	15±6	19±1
A-10	3±2*	1±1	19±1
Smelter Hill			
B-2	14±6	5±4	19±1
B-3	19±1	10±6	18±2
B-4	12±3	6±3	18±1
B-5	19±1	6±5	18±1
B-9	2±1*	3±2	16±2
B-11	18±1	0	19±1
B-13	15±8	3±3	18±2
B-16	14±3	7±5	19±1
Mount Haggin			
C-1	13±6	3±3	19±1
C-3	19±1	7±5	19±1
C-5	4±2*	16±3	16±5
C-7	8±5*	16±6	19±1
C-9	3±4*	12±5	19±1
C-12	17±1	0	18±1
C-14	19±0	10±7	19±0
Riparian control			
RR7,13	20±0	9±9	19±1
Riparian impact			
R-4	0*	0*	0*
R-8	2±1*	0±0*	4±3*
R-13	8±2*	1±1*	16±2
R-14	0*	0*	0*
OP-2	1±1*	0±1*	3±1*

Values are mean ± standard deviation of five replicates. Each replicate contained 20 seeds.
* indicates values significantly less than the control value using t-test at the α = 5% level.
Tests were conducted on arcsin square root transformed percentages.

Table 4-6
Shoot Height and Root Length of Alfalfa, Lettuce, and Wheat (mm)

Sample	Alfalfa Shoot	Alfalfa Root	Lettuce Shoot	Lettuce Root	Wheat Shoot	Wheat Root
Upland controls						
AA-3	34±10	65±33	15±5	21±12	110±48	138±56
BB-2	39±12	90±42	42±13	43±27	189±49	171±58
BB-9	42±11	101±43	32±14	43±26	166±54	178±47
BB-13	29±8	70±23	32±10	43±26	111±47	67±40
BB-3,15	37±10	77±37	39±15	64±29	163±66	182±65
CC-3	37±8	111±35	54±17	54±20	187±42	218±47
CC-5	37±14	81±36	39±17	49±23	170±37	182±46
CC-14	35±9	41±23	10	2	152±44	161±60
Upland impact						
Stucky Ridge						
A-2	36±10	43±25*	39±13	36±17	174±57	82±34
A-3	15±5*	7±6*	17±8	14±11	90±69	25±12*
A-6	15±4*	4±2*	11±3	2±1*	83±27*	7±3*
A-8	32±10	57±22	23±10	28±12	154±36	165±34
A-10	7±4*	4±2*	4±1*	3±1*	36±14*	4±2*
Smelter Hill						
B-2	19±5*	11±8*	20±4	5±3*	96±28	44±24*
B-3	31±10	43±20*	33±NC	43±19	166±57	110±38
B-4	16±5*	6±4*	10±4*	2±1*	43±24*	9±3*
B-5	27±8	33±12*	30±12	23±12	149±43	129±43
B-9	10±2*	2±1*	9±NC	44	48±16*	6±3*
B-11	10±2*	5±2*	0*	0*	72±22*	11±6*
B-13	12±6*	9±3*	24±9	26±15	44±18*	24±13*
B-16	16±6*	12±5*	14±5	8±3*	145±46	54±24*
Mount Haggin						
C-1	13±4*	12±7*	6±2*	5±2*	104±79	33±19*
C-3	37±7	65±20	41±8	50±13	165±52	171±45
C-5	16±8*	18±8*	13±4	7±5*	108±31	25±7*
C-7	16±6*	16±16*	20±6	11±5	98±45	29±9*
C-9	16±4*	11±5*	13±3	4±2*	105±35	15±6*
C-12	26±6	25±16*	0*	0*	100±30	69±45*
C-14	17±5*	21±5*	10±3*	8±2*	113±32	18±7*
Riparian control						
RR7,13	47±8	78±29	33±11	30±14	203±59	178±44
Riparian impact						
R-4	0*	0*	0*	0*	0*	0*
R-8	0*	0*	0*	0*	23±9*	0*
R-13	12±14*	3±1*	11±3*	2±1*	37±22*	4±4*
R-14	0*	0*	0*	0*	27*	0*
OP-2	4±0*	5±1*	8±4*	13*	15±7*	0*

Values are mean ± standard deviation of five replicates. NC = Not calculated.
* indicates values significantly less than the control value using t-test at the α = 5% level.

4.2.2.1 Riparian

Results of t-tests for riparian soils screening tests are summarized below; values that differ significantly from the control mean are indicated in Table 4-6.

- Alfalfa, lettuce, and wheat shoot height and root length for all six impact sites tested, including the Opportunity Ponds, were significantly less than values determined for the control.

4.2.2.2 Upland

For each upland impact site, the mean value of each response variable per species (shoot height, and root length) was compared to the mean value of the same response variable determined from the control samples using a t-test. Results are summarized below; values that differ significantly from the control mean are indicated in Table 4-6.

- Alfalfa shoot height was significantly less than the mean shoot height of control plants in 14 of the 20 impact soils tested.
- Alfalfa root length was significantly less than the mean root length of control plants in 18 of the 20 impact soils tested.
- Lettuce shoot height was significantly less than the mean shoot height of control plants in five of the 20 impact soils tested.
- Lettuce root length was significantly less than the mean root length of controls plants in 11 of the 20 impact soils tested.
- Wheat shoot height was significantly less than the mean shoot height of control plants in six of the 20 impact soils tested.
- Wheat root length was significantly less than the mean root length of controls in 15 of the 20 impact soils tested.

4.2.3 Mass

Following measurement of height of shoots and maximum length of roots, seedlings were oven dried and weighed. Because of the limited amount of tissue, alfalfa and lettuce seedlings were pooled to obtain a single mass for each replicate series, but wheat shoots and roots were weighed individually (Table 4-7).

Table 4-7
Shoot and Root Mass of Alfalfa, Lettuce, and Wheat (g)

Sample	Alfalfa		Lettuce		Wheat	
	Shoot	Root	Shoot	Root	Shoot	Root
Upland controls						
AA-3	0.281	0.161	0.014	0.005	0.888	1.054
BB-2	0.407	0.251	0.121	0.056	1.673	1.533
BB-9	0.380	0.358	0.087	0.092	1.223	1.697
BB-13	0.248	0.213	0.049	0.087	0.878	0.842
BB-3,15	0.335	0.216	0.103	0.070	1.191	1.519
CC-3	0.302	0.229	0.067	0.024	1.759	1.702
CC-5	0.319	0.354	0.067	0.048	1.805	2.148
CC-14	0.339	0.177	0	0	1.621	2.532
Upland impact						
Stucky Ridge						
A-2	0.191	0.306	0.064	0.134	1.706	1.033
A-3	0.063*	0.014*	0.006	0.001	0.692*	0.478*
A-6	0.101*	0.026*	0.020	0.002	0.909	0.744*
A-8	0.403	0.219	0.068	0.093	1.650	1.982
A-10	0.001*	0.002*	0.004	0.002	0.422*	0.593*
Smelter Hill						
B-2	0.123*	0.024*	0.020	0.003	0.951	0.871
B-3	0.259	0.147	0.102	0.051	1.779	1.368
B-4	0.083*	0.016*	0.018	0.003	0.429*	0.324*
B-5	0.285	0.155	0.045	0.020	1.416	1.312
B-9	0.001*	0.008*	0.002	0.013	0.557*	0.661*
B-11	0.140	0.040*	0	0	0.752*	0.990*
B-13	0.105	0.043	0.009	0.004	0.687	0.673
B-16	0.165	0.060	0.033	0.016	1.636	1.071
Mount Haggin						
C-1	0.076*	0.023*	0.011	0.003	1.065	1.477
C-3	0.397	0.404	0.086	0.054	1.568	1.703
C-5	0.013*	0.030*	0.085	0.033	0.992	0.843
C-7	0.067*	0.024*	0.044	0.025	0.915	1.344
C-9	0.031*	0.013*	0.052	0.014	1.198	0.783*
C-12	0.201	0.124	0	0	0.946	1.172
C-14	0.206	0.097	0.033	0.015	1.213	0.957
Riparian control						
RR7,13	0.587	0.373	0.089	0.052	1.946	2.541
Riparian impact						
R-4	0*	0*	0*	0*	0*	0*
R-8	0*	0*	0*	0*	0.091*	0*
R-13	0.059*	0.005*	0.002*	0*	0.878	0.842
R-14	0*	0*	0*	0*	0.004*	0*
OP-2	0.004*	0.002*	0.002*	0.006*	0.086*	0*

Values are totals for the five replicates.
* indicates values significantly less than the control value using t-test at the α = 5% level.

4.2.3.1 Riparian

Results of riparian t-tests are summarized below and values that differ significantly from the control mean are indicated in Table 4-7. Growth values for alfalfa and wheat shoot and root mass are illustrated in Figure 4-12(a,b).

- Shoot and root masses of alfalfa and lettuce were significantly less than masses determined for the control sample in all six riparian impact soils tested.
- Wheat shoot and root mass was significantly less than the control in five of the riparian impact soils tested.

4.2.3.2 Upland

For each upland impact site, the mean value of each response variable per species (shoot mass; root mass) was compared to the mean value of the same response variable determined from the control samples using a t-test. Results summarized below and values that differ significantly from the control mean are indicated in Table 4-7. Growth values for alfalfa and wheat mass are illustrated in Figures 4-13(a,b), 4-14(a,b) and 4-15(a,b).

- Alfalfa shoot mass was significantly less than the mean value of shoot mass for control plants in 11 of the 20 upland impact soils tested.
- Alfalfa root mass was significantly less than the mean value of root mass for control plants in 12 of the 20 upland impact soils tested.
- Wheat shoot mass was significantly less than the mean value of shoot mass for control plants in 5 of the 20 upland impact soils tested.
- Wheat root mass was significantly less than the mean value of root mass for control plants in 12 of the 20 upland impact soils tested.

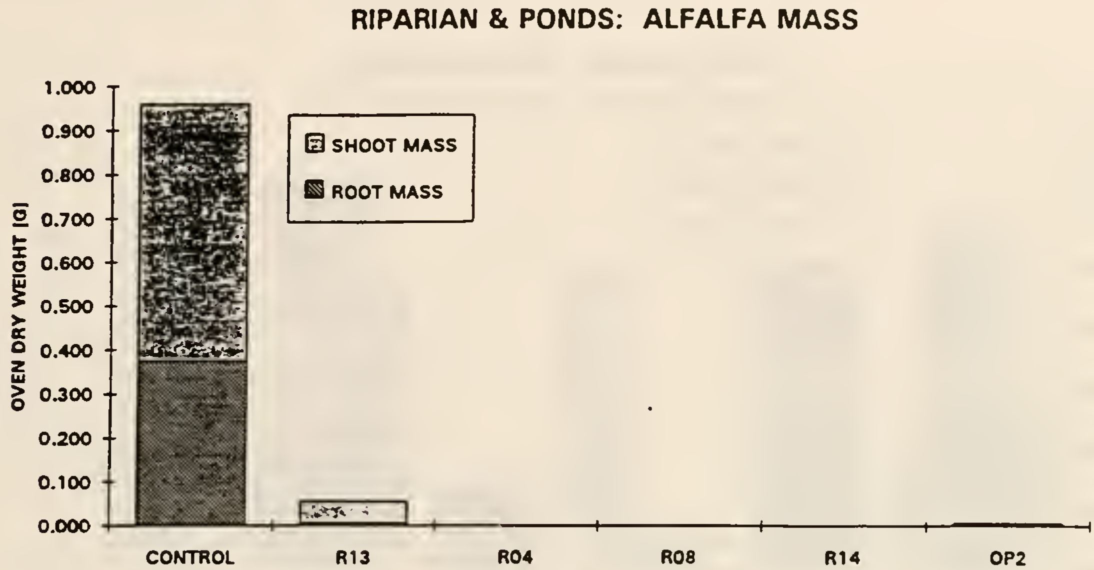

Figure 4-12a. Shoot and Root Mass (g) of Alfalfa Seedlings Grown in Soils from Silver Bow Creek (R-04, R-08) and the Clark Fork River (R-13, R-14) Floodplains and the Opportunity Ponds (OP-2). All tissues in each replicate series were pooled to obtain a single root mass and shoot mass for each site.

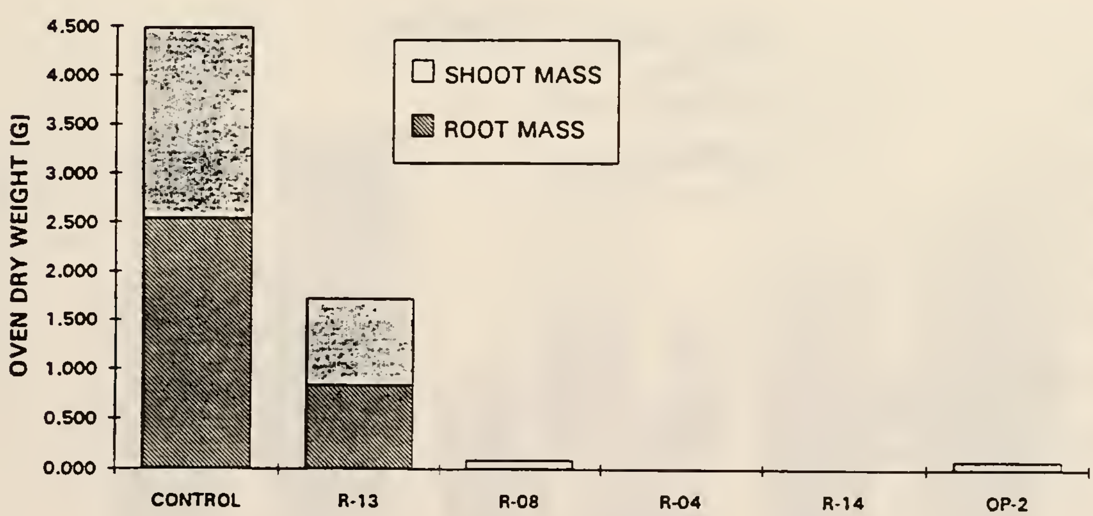

Figure 4-12b. Shoot and Root Mass (g) of Wheat Seedlings Grown in Soils from Silver Bow Creek (R-04, R-08) and the Clark Fork River (R-13, R-14) Floodplains and the Opportunity Ponds (OP-2).

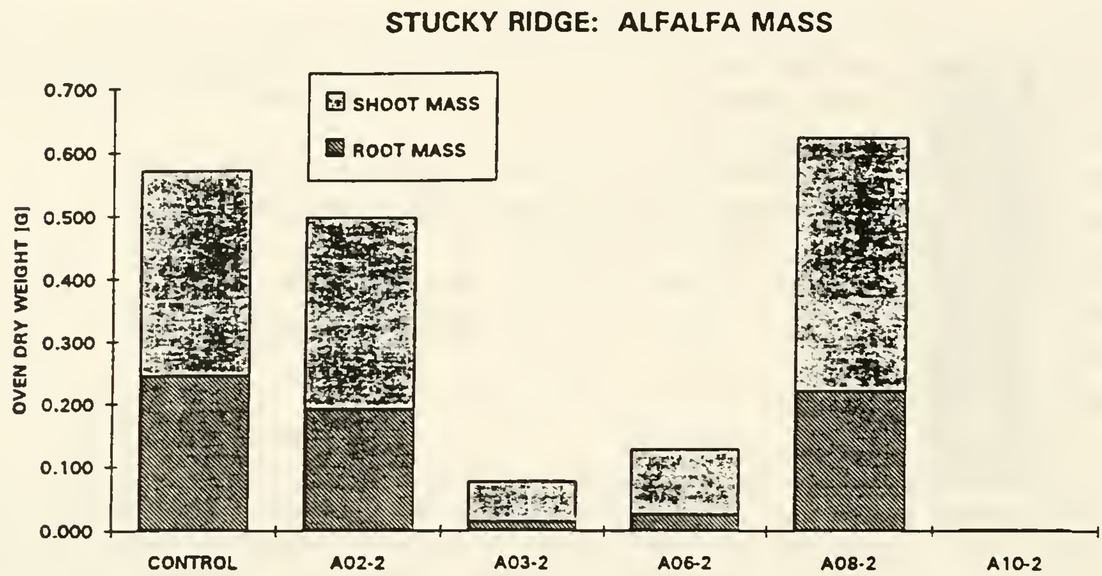

Figure 4-13a. **Shoot and Root Mass (g) of Alfalfa Seedlings Grown in Soils from Stucky Ridge.**

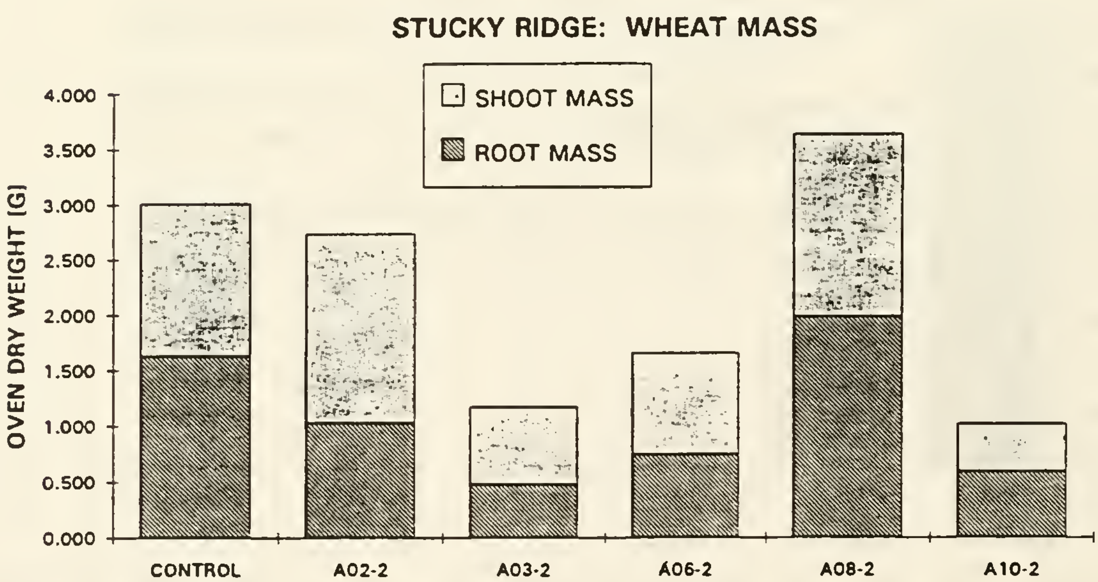

Figure 4-13b. **Shoot and Root Mass (g) of Wheat Seedlings Grown in Soils from Stucky Ridge.**

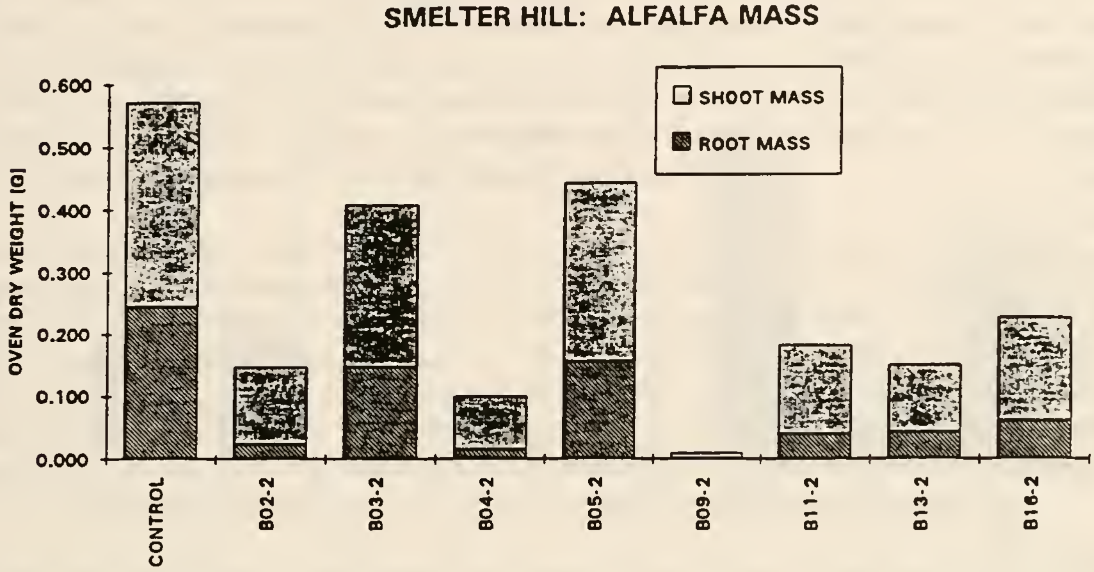

Figure 4-14a. **Shoot and Root Mass (g) of Alfalfa Seedlings Grown in Soils from Smelter Hill.**

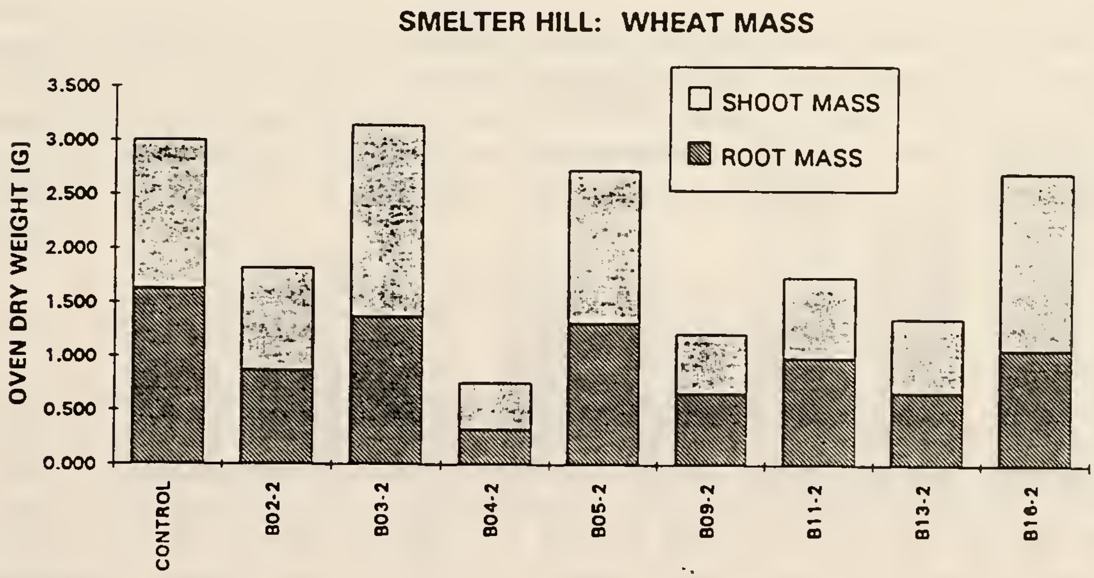

Figure 4-14b. **Shoot and Root Mass (g) of Wheat Seedlings Grown in Soils from Smelter Hill.**

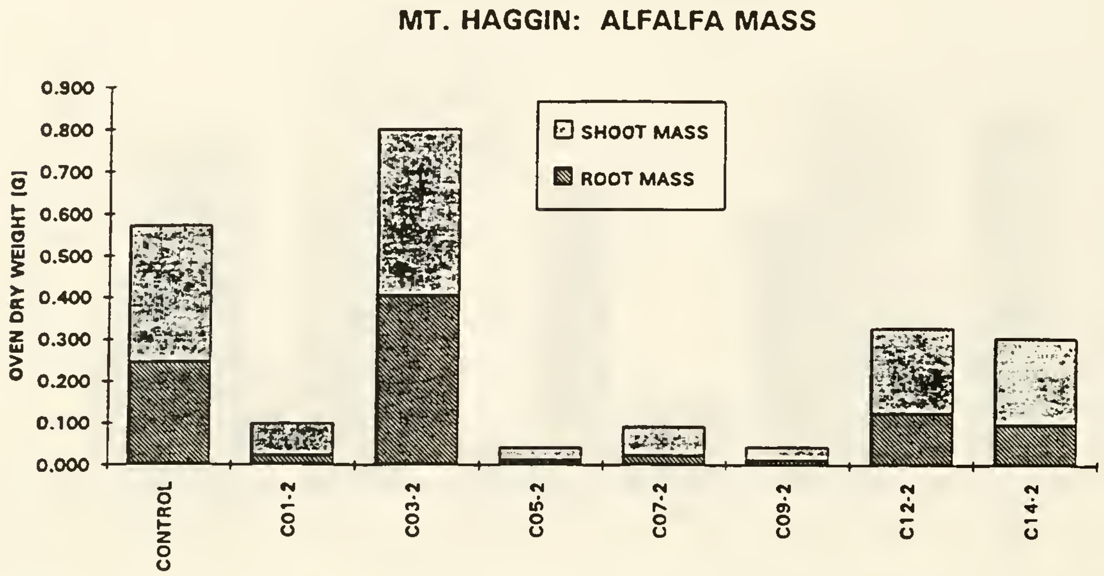

Figure 4-15a. **Shoot and Root Mass (g) of Alfalfa Seedlings Grown in Soils from Mount Haggin.**

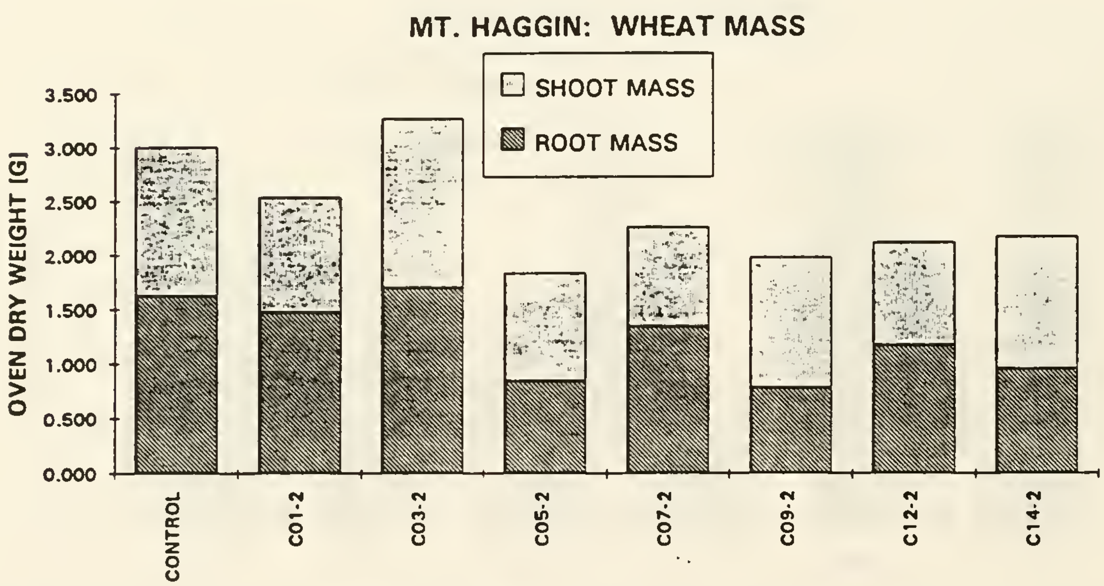

Figure 4-15b. **Shoot and Root Mass (g) of Wheat Seedlings Grown in Soils from Mount Haggin.**

4.3 SPECIES - ENDPOINT TOXICITY SCORES

Toxicity scores derived from statistical analyses of the screening tests were tabulated for each species endpoint (all relevant data are included in the appendix). Assignment of each toxicity score was based on the relative difference from the control mean (Section 3.4). Tables 4-8 and 4-9 present upland and riparian toxicity scores by species endpoint and sample site. The vertical totals constitute the overall site toxicity index, derived by summing the individual species-endpoint responses of all trials in soil from a single site.

Phytotoxicity response categorization (Table 4-10) was based on the site toxicity index, ranging from < 0.5 for nontoxic, and ≥ 0.5 to 9 for mildly toxic to 72 for severely toxic (Table 3-5). Of the riparian sites tested, 100% were classified as Severely Phytotoxic (a site toxicity index in the range of 36.1 to 72). Of the 20 upland sites, 90% (18) were phytotoxic: 5% of the upland sites were severely phytotoxic, 55% were highly phytotoxic (site toxicity index in the range of 18.1 to 36), 10% were moderately phytotoxic (site toxicity index in the range of 9.1 to 18), and 20% were mildly phytotoxic (site toxicity index in the range of 0.5 to 9). The remaining 10% of upland sites were nontoxic relative to control plants.

By sites, the distribution of phytotoxic soil samples was: Stucky Ridge, four of five (80%); Smelter Hill, eight of eight (100%); and Mt. Haggin, six of seven (86%).

4.4 RELATIVE TOXICITY AMONG TEST SPECIES AND ENDPOINTS

Relative toxicity varied among the standard plant test species. Toxicity scores for all upland samples were totaled and are presented by species and endpoint in Table 4-11 to aid in discussion of specific phytotoxic effects observed (theoretical maximum score in the alfalfa, lettuce, and wheat columns is 80). The vertical totals indicate relative toxicity by species; the horizontal totals indicate which endpoints were most affected. The order of species response relative to control soils was most pronounced in alfalfa, intermediate in wheat, and least in lettuce.

4.4.1 Impact on Roots

Root growth was consistently the most affected endpoint (18 of 20 site soils); reduction in root growth was observed in both length and mass (Tables 4-6, 4-7, 4-8, and 4-11). The result is typical of response to toxic metals (Clark, et al., 1981; Smith and Brenna, 1983; Berry, 1977; Krawczyk, et al., 1988; Atkinson, 1985; Fairley, 1985; Fitter, 1985; Alloway, 1990; ICF, 1989). Nutrient deficiency, in contrast, typically causes *increased* root length and equivalent or slightly reduced root mass relative to plants grown in nutrient sufficient conditions.

Table 4-8
Upland Species-Endpoint Toxicity Scores

	A-2	A-3	A-6	A-8	A-10	B-2	B-3	B-4	B-5	B-9	B-11	B-13	B-16	C-1	C-3	C-5	C-7	C-9	C-12	C-14
Alfalfa																				
Germination					2					4						2	1	2		
Shoot height		2	2		4	1		2		2	2	2	2	2		2	2	2		2
Root length	1	4	4		4	4	1	4	2	4	4	4	4	4		4	4	4	2	2
Shoot mass		4	2		4	2		2		4		2		4		4	4	4		
Root mass		4	4		4	4		4		4	4	4	4	4		4	4	4		
Total mass		4	4		4	2		4		4	2	2		4		4	4	4		
Lettuce																				
Germination																				
Shoot height					4					2	4			4					4	2
Root length			4		4	4		4			4			4		4		4	4	
Shoot mass																				
Root mass																				
Total mass																				
Wheat																				
Germination																				
Shoot height					4			2		2	2	2								
Root length		4	4		4	2		4		4	4	4	2	4		4	4	4	2	4
Shoot mass					2			2		2										

Table 4-8 (cont.)
Upland Species-Endpoint Toxicity Scores

	A-2	A-3	A-6	A-8	A-10	B-2	B-3	B-4	B-5	B-9	B-11	B-13	B-16	C-1	C-3	C-5	C-7	C-9	C-12	C-14
Root mass		2	2		2			4		2		2						2		
Total mass		2			2			2		2		2								
Site toxicity	1	26	26	0	44	19	1	34	2	36	26	24	12	30	0	28	23	30	12	8

Notes: Toxicity scores for endpoints by site and by species. Vertical totals constitute the site toxicity index. Scores were calculated based on the results of t-tests comparing impact plant performance to control plant performance.

Table 4-9
Species-Endpoint Scores for Riparian Soils

	R-4	R-8	R-13	R-14	OP-2
Alfalfa					
Germination	4	4	0	4	4
Shoot height	4	4	2	4	4
Root length	4	4	4	4	4
Shoot mass	4	4	4	4	4
Root mass	4	4	4	4	4
Total mass	4	4	4	4	4
Lettuce					
Germination	4	4	4	4	4
Shoot height	4	4	0	4	0
Root length	0	0	0	0	0
Shoot mass	4	4	0	4	0
Root mass	0	0	0	0	0
Total mass	0	0	0	0	0
Wheat					
Germination	4	0	0	4	0
Shoot height	4	4	4	4	4
Root length	4	4	4	4	4
Shoot mass	4	4	0	4	4
Root mass	4	4	0	4	4
Total mass	4	4	0	4	4
Site toxicity index	60	56	30	60	48

Scores were calculated based on results of t-tests using an assumption of unequal variances between riparian impact and control samples. Vertical totals constitute the site toxicity index.

Table 4-10
Site Toxicity Indices Determined from Seedling Emergence and Growth Performance of Alfalfa, Lettuce, and Wheat

	Stucky Ridge	Smelter Hill	Mt. Haggin	Riparian Sites	% of Upland Samples	% of Riparian Samples	% of All Samples
Severely phytotoxic	A-10			R-4 R-8 R-13 R-14 OP-2	5	100	24
Highly phytotoxic	A-3 A-6	B-2 B-4 B-9 B-11 B-13	C-1 C-5 C-7 C-9		55	0	44
Moderately phytotoxic		B-16	C-12 C-14		15	0	12
Mildly phytotoxic	A-2	B-3 B-5			15	0	12
Nontoxic	A-8		C-3		10	0	8
% of phytotoxic samples	80	100	86		100	100	100

Comparisons are relative to seedling emergence and growth in control soils. Toxicity categories are described in Section 3-4 and Table 3-5.

Reduction in root viability of alfalfa has further implications regarding soil recovery and the establishment and maintenance of a complex plant community. Legume and actinorrhizal species (e.g., alfalfa, peas, conifers) form complex associations with soil biota, resulting in root nodule formation (Curtis, 1983; Fitter and Hay, 1987). Root nodules are the loci of dinitrogen fixation; nitrogen formation adds a substantial quantity of nitrogen to the soil and contributes to development of nutrient-rich soil (Ludden and Burris, 1985; Evans, et al., 1985; Kapustka, 1987). Nodules (and symbiotic plant-bacterial associations) only form on healthy root systems. The response of test species and the observed absence of cyanobacteria (mosses, lichens, and crusts common to soil surfaces) in the impact areas indicate long-term impairment of the capacity of the soil to support nitrogen fixation. This deficiency represents a sustained injury that will continue to limit the development of a complex and diverse vegetation community in the impact area.

Table 4-11
Toxicity Endpoint Score from All Upland Samples

	Alfalfa	Lettuce	Wheat	Total = Relative Toxicity to Endpoint
Germination	11	0	0	11
Shoot height	29	20	12	61
Root length	60	36	54	150
Shoot mass	36	0	6	42
Root mass	52	0	16	68
Total mass	42	0	10	52
Total = Relative toxicity to species	230	56	98	384

The vertical totals indicate relative toxicity by species.

Wheat toxicity was also noted primarily in root performance, both root length and root mass (Tables 4-6, 4-7, 4-8, and 4-11). The performance of wheat is consistent with the field observations and literature on metal toxicity. The extent of colonization of impact areas by Great Basin wild rye and red top indicates the hardiness of these grasses. Studies of similar sites (Bunker Hill (ID), Sudbury (Ontario), and sites in Oklahoma and the United Kingdom) also contaminated by metals have shown local resistance by selected grasses (Wu and Antonovics, 1975; Reilly and Reilly, 1973; Symionides et al., 1985; Baker, 1981; Gibson and Pollard, 1988).

4.4.2 Impact on Shoots

Shoot growth differences among site soil treatments and control soils were less pronounced than for roots, particularly for wheat plants (Table 4-11). The impact from soil contaminants, especially toxic metals, on shoot physiology occurs after uptake and assimilation in roots. Of the three species tested, wheat has the greatest amount of stored energy and nutrients in the seed reserve tissues (cotyledons or endosperm), and lettuce has the least. During early seedling growth stages, the young plant draws extensively from the storage reserves. As seedlings develop into mature plants, the shoot becomes dependent on photosynthesis for energy; nutrients are transported from roots to the shoots. In wheat, remnants of seeds were attached to the seedlings at harvest (2-weeks), suggesting that the shoots were still dependent on seed storage reserves to some extent. The plant with larger reserves is less dependent on (and less responsive) to environmental stresses.

5.0 STATISTICAL RELATIONSHIPS BETWEEN PHYTOTOXICITY AND HAZARDOUS SUBSTANCE CONCENTRATIONS IN UPLAND SOILS

It has been demonstrated that soils collected from impacted areas surrounding the Anaconda Smelter (Smelter Hill, Stucky Ridge, Mt. Haggin) contain significantly elevated concentrations of hazardous substances relative to control soils (see Appendix A) and are significantly phytotoxic relative to control soils. Further, these phytotoxic impacted areas have significantly reduced vegetative cover, including percent cover, number of vegetative habitat layers, and presence of dominance types (see Appendix C).

The site samples ranked as nontoxic or mildly toxic (Table 4-10) either have low contaminant concentrations (e.g., B-03) or high pH (e.g., A-08, A-02, B-05, and C-03) (see Appendix A). High pH, especially pH ~ 7 and above, greatly reduces the bioavailability of metals and explains the non-phytotoxic responses to these soils. Conversely, the low pH soils and high contaminant concentrations are generally associated with the site samples ranked as highly toxic or severely toxic. Three additional statistical points support the conclusion that hazardous substances in upland soils have *caused* the observed injury.

1. **Metals concentrations exceed phytotoxic thresholds.**

Mean concentrations of arsenic, copper, and zinc from the impact areas are substantially higher than those known to cause phytotoxic responses in controlled laboratory experiments (Table 5-1). Mean concentration of arsenic in impact areas was 7-24 times higher than known phytotoxic concentrations, and mean copper concentrations were 6-14 times higher than known phytotoxic concentrations. Mean concentrations of cadmium, lead, and zinc were higher than phytotoxic concentrations reported in some studies.

Table 5-1
Ranges of Minimum Soil Concentrations Reported to Cause Phytotoxicity (summarized by Kabata-Pendias and Pendias, 1992) and Ratios of Mean Impact Area Concentrations to Phytotoxic Levels

Metal	Minimum Concentrations Causing Phytotoxicity	Mean Impact Area Concentrations: Phytotoxic Threshold
Arsenic	15 - 50	7.3 - 24.6
Copper	60 - 125	6.7 - 14.1
Cadmium	3 - 5	2.3 - 3.0
Lead	100 - 400	0.4 - 1.8
Zinc	70 - 400	0.9 - 5.0

Values > 1 indicate that average impact soils concentrations are greater than phytotoxic threshold.

2. Phytotoxicity is consistent with concentration and pH trends.

Figure 5-1 presents a scatter plot of copper and arsenic concentrations (the hazardous substances with the greatest ratio of concentration:phytotoxic threshold, Table 5-1), and soil pH. For each sample site, the degree of phytotoxicity is indicated with a symbol (e.g., highly toxic sites appear as solid squares; nontoxic impact sites appear as open triangles; control sites appear as open circles).

Control sites have lower concentrations of both arsenic and copper, while highly and severely toxic sites tend to have more elevated concentrations of both hazardous substances.

The figure also demonstrates the well-documented mediating influence of soil pH on metal availability and toxicity (Kabata-Pendias and Pendias, 1992): as pH increases (e.g., pH > 7) sites are either mildly toxic or nontoxic (except for a single highly toxic site with extremely elevated copper concentration).

3. Phytotoxicity is correlated with metals concentrations.

Statistically significant relationships were found to exist between *concentrations* of hazardous substances and the *degree* of phytotoxicity measured in impacted soils samples. This "dose-response" relationship (i.e., degree of phytotoxicity positively correlated with the *concentration* of hazardous substances) provides additional evidence of the causal linkage between the hazardous substances in impacted soils areas, and the observed injury to vegetation.

Relationships between phytotoxicity scores and metal concentrations were examined using nonparametric correlation. Nonparametric correlation measures the concordance between the rankings of paired observations. It is not sensitive to departures from normality and does not attempt to measure the degree of linearity of the relationship between two variables, which is appropriate in this application because the nature of the dose-response relationship between metal concentration and toxicity is not hypothesized to be linear. In this study, the phytotoxicity rating is an amalgam of various phytotoxicity endpoints, and the measured endpoints (germination rate, shoot length, etc.) that comprise each phytotoxicity score are likely to be mutually correlated. This feature and the fact that the scoring system gives equal weight to each type of endpoint, suggests that the scale of phytotoxicity scores may be ordinal rather than interval. Nonparametric correlation is appropriate when the scale of measurement is at least ordinal (Conover, 1980).

A simplified transformation based on solubility relationships (Stumm and Morgan, 1980; Drever, 1982) was adopted to approximate the relationship of the bioavailable fraction of total metals and acidity, for correlation analysis. Metals concentrations were adjusted for soil pH for each individual site to derive a "surrogate" for bioavailability using the following transformation:

$$[M_b] = [M_t] \times [H^+] \times 10^{12} \qquad \text{(Equation 1)}$$

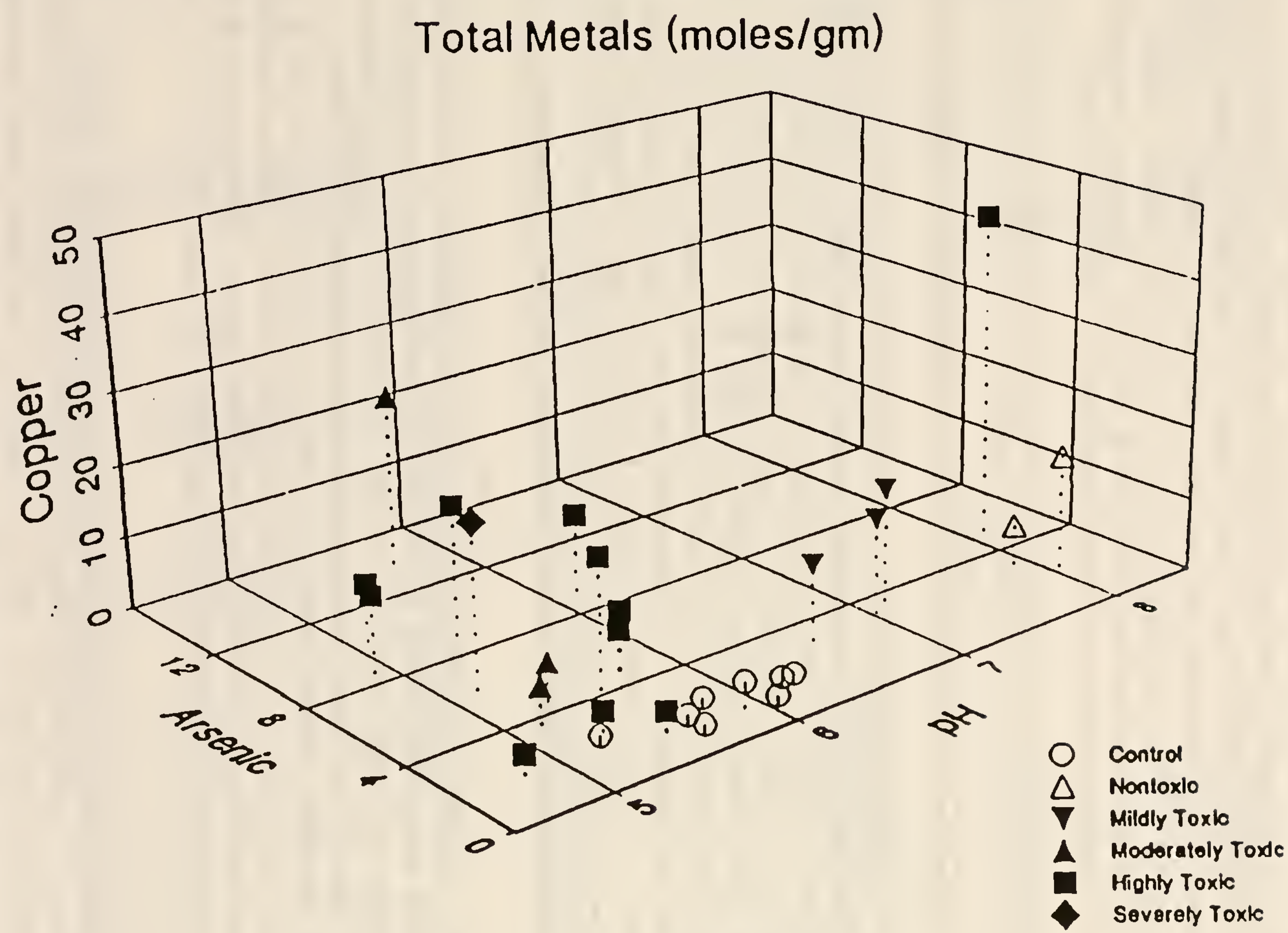

Figure 5-1. Scatter Plot of Total Arsenic and Total Copper (moles/gm), and pH at Sites Tested for Phytotoxicity. Solid symbols indicate toxic sites; open symbols indicate nontoxic impact sites and control sites. Soils that were nontoxic exhibited either high pH or low arsenic and copper concentrations.

where M_b represents the metal concentration adjusted for hydrogen ion concentration (pH), or the bioavailability surrogate, and M_t represents the actual measured total metals concentration. Multiplication by the constant 10^{12} is an aid for representational purposes and has no effect on correlation coefficients or significance levels.

The correlation between phytotoxicity and biologically available metals (M_b) for each metal was positive and highly significant ($p \leq 0.005$ in all cases; Table 5-2). The highest degree of correlation with phytotoxicity was for copper, arsenic, and lead; the lowest was for cadmium. Correlations *among* the metals were all positive and highly significant ($p < 0.005$ in all cases), which is probably indicative of their common source (the smelter at Anaconda). Similarly, the correlation between pH and each metal was negative and highly significant ($p < 0.005$ in all cases).

Table 5-2
Kendall-τ Correlations Between Phytotoxicity Score and $[H^+]$-Adjusted Metal Concentration (M_b)

	Phytotoxicity Score	As_b	Cu_b	Cd_b	Pb_b	Zn_b
As_b	0.48					
Cu_b	0.52	0.90				
Cd_b	0.41	0.84	0.83			
Pb_b	0.48	0.90	0.85	0.88		
Zn_b	0.44	0.92	0.87	0.88	0.90	
$[H^+]$	0.39	0.80	0.71	0.73	0.81	0.78

$p < 0.005$ in all cases, under the hypothesis H_0: $\tau \leq 0$ vs. H_a: $\tau > 0$, n = 28.

Since the range of pH measured in impact samples was within the range that is generally tolerable for plants, it is unlikely that pH has a direct influence on phytotoxicity despite the significant correlation that was observed. More likely, the correlation between pH and phytotoxicity is a by-product of the high degree of correlation between metals concentrations and pH. To be conservative, partial correlations between phytotoxicity and M_b were examined to account for any possible *direct* effect of pH (Table 5-3). The partial correlations reflect the degree of relationship between metal concentrations and phytotoxicity if pH were held constant. The analysis indicated a significant positive relationship between phytotoxicity and copper and arsenic ($p < 0.01$), as well as with lead and zinc ($p < 0.05$).

The results of the partial correlations suggest that elevated copper, arsenic, lead, and zinc concentrations are likely to be the proximal cause of the observed phytotoxicity. However, since the average concentrations of all hazardous substances measured in the upland impact areas were in exceedence of known thresholds for phytotoxicity, it is probable that all of the elevated metals and arsenic contributed to the phytotoxic responses observed in the laboratory.

Table 5-3 **Kendall-τ Partial Correlation Coefficients Between Phytotoxicity Score and Bioavailable Metal Concentration (M_b), with Partialling Variable $[H^+]$, n = 28**	
Variable	**Phytotoxicity Score**
As_b	0.31**
Cu_b	0.38**
Cd_b	0.20
Pb_b	0.30*
Zn_b	0.24*
* and ** indicate $p < 0.05$ and $p < 0.01$, respectively (quantiles approximate; Siegel and Castellan, 1988).	

When control sites were conservatively excluded from the correlation analysis, the correlation between phytotoxicity and pH-adjusted metal concentrations was less pronounced (Table 5-4). As before, all five hazardous substances showed significant positive correlations with phytotoxicity, with copper and arsenic having the highest degree of correlation. Partial correlations (with correction for pH) were found to be significant between phytotoxicity and copper and arsenic (Table 5-5). Thus, even in the more conservative analysis (impact samples only) concentrations of hazardous substances were found to be positively correlated with phytotoxicity, indicating the causal connection between concentrations of hazardous substances and injury to vegetation.

Table 5-4
Kendall-τ Correlations Between Phytotoxicity Score and pH-Adjusted Metal Concentration (M_b)

	Phytotoxicity Score	As_b	Cu_b	Cd_b	Pb_b	Zn_b
As_b	0.51**					
Cu_b	0.52**	0.92**				
Cd_b	0.37*	0.79**	0.83**			
Pb_b	0.47**	0.87**	0.79**	0.83**		
Zn_b	0.46**	0.88**	0.86**	0.84**	0.86**	
$[H^+]$	0.50**	0.79**	0.70**	0.70**	0.84**	0.73**

* and ** represent $p < 0.05$ and $p < 0.01$, respectively, under the hypothesis H_o: $\tau \leq 0$ vs. H_a: $\tau > 0$, n = 20.

Table 5-5
Kendall-τ Partial Correlation Coefficients Between Phytotoxicity Score and Bioavailable Metal Concentration (M_b), with Partialling Variable pH, n = 20

Variable	Phytotoxicity Score
As_b	0.21*
Cu_b	0.27**
Cd_b	0.03
Pb_b	0.09
Zn_b	0.15

* and ** indicate $p < 0.05$ and $p < 0.10$, respectively (quantiles approximate; Siegel and Castellan, 1988).

6.0 CONCLUSIONS

The analysis of phytotoxicity data supports four specific conclusions:

1. Soil and vegetation resources of the riparian impact area and all three upland areas (Stucky Ridge, Smelter Hill, and Mt. Haggin) are injured.

2. Within each upland area, site-specific variation in toxicity was demonstrated.

3. The patterns of plant response are consistent with theoretical expectations for plants exposed to contaminant conditions (arsenic, copper, zinc, and pH).

4. The degree of phytotoxicity, as evaluated by weighting factors, correlates with exposure concentrations of hazardous substances.

The riparian impact soils (including Opportunity Ponds) were the most toxic of all the samples tested in this study. The phytotoxic effects on hybrid poplar (selected as a representative for willows and cottonwood; resident, native trees and shrubs), were severe and rapid: all impact plants were dead at the conclusion of the tests. Screening level tests with alfalfa, lettuce, and wheat on the riparian samples revealed severe toxicity in 100% of the soils tested. The phytotoxicity exhibited in the tests with hybrid poplar and alfalfa, wheat, and lettuce is consistent with the field observations of the riparian zone vegetation. The riparian impact zones are noteworthy in terms of the absence of vegetation (see Terrestrial Injury Assessment Report). The riparian soils contained extremely high concentrations of hazardous substances and low pH.

Mixing the riparian impact soils with equal amounts of control soil appears to relieve most, if not all, the phytotoxicity. Nevertheless, the riparian impact soils, as they currently exist in the field,

are sufficiently toxic to eliminate virtually all plant establishment, either by vegetative extension or from seeds.

The upland impact soils also indicated substantial injury to plants: 5% of the upland sites were severely phytotoxic, 55% were highly phytotoxic, 10% were moderately phytotoxic, and 20% were mildly phytotoxic. The remaining 10% of upland sites were nontoxic relative to control plants.

The vegetation conditions in the field and the laboratory toxicity results are consistent with expectations of soil contamination with toxic metals. The levels of contamination, especially of arsenic, copper, and zinc and to a lesser extent of cadmium and lead, indicate past and long-term sustained injury to plants.

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ATTACHMENT A

Table A-1. Field work checklist.	
TASK	SITE
Photograph Site And Surrounding Vegetation	
Plant Collections for Chem. Analysis	
Conifer Needles	
Conifer Stems	
Deciduous Tree Leaves	
Deciduous Tree Stems	
Shrubs	
Forbs	
Graminoids	
Swipe Sample (tissue paper)	
Collect Vouchers	
Record Descriptions	
Tree Measurements	
Root Samples	

Table A-2. Plants noted in field samples.			
Collection Area	Genus species	Common name	Site
Stucky Ridge			
	Agrostis alba	Redtop	A10-5
	Centaurea maculosa	Knapweed	A3-5
	Chrysothamnus nauseosus	Rabbit Brush	A10-5
	Cirsium sp.	Thistle	A3-5;A10-5
	Elymus cinereus	Great Basin Wild Rye	A6-5
	Orysopsis hymenoides	Indian Rice Grass	A3-5
	Pinus flexilis	Limber pine	A3-5
	Rosa woodsii	Rose	A6-5
Smelter Hill			
	Agrostis alba	Redtop	B5-6
	Apocynum cannabinum	Dogbane	B13-6
	Aster adscendens	Western Aster	B16-6
	Aster conspicuons **	Rough Aster	B5-6
	Aster sp.	Aster	B13-6
	Carex sp.	Sedge	B11-6
	Centaurea maculosa	Knapweed	B3-6, B16-6
	Chrysothamnus nauseosus	Rabbitbrush	B3-6
	Chrysothamnus viscidiflorous		B11-6
	Elymus cinereus	Great Basin Wild Rye	B3-6, B16-6, B11-6
	Epilobium angustifolium	Fireweed	B5-6
	Gindelia squarrosa	Curly Cup Gum Weed	B16-6
	Grindelia squarrosa	Broad-leaved Gum-plant	B16-6
	Gutierrezia sarothrae	Broom Snake Weed	B3-6
	Heuchera parvifolia	Alumroot	B11-6
	Mahonia repens	Oregon Grape	B5-6
	Mentzelia sp.		B13-6
	Pinus flexilis	Limber Pine	B3-6
	Poa juncifolia	Alkali Bluegrass	B3-6
	Populus tremuloides	Quaking aspen	B5-6
	Smilacena stellata	False Solomon's Seal	B5-6
	Euphorbia esula	Leafy Spurge	B13-6
	Tetradymia canescens	Horse Brush	B16-6
	Tragopogon dubius		B13-6

Table A-2. Continued.			
Collection Area	Genus species	Common name	Site
Mt. Haggin			
	Agropyron caninum	Slender Weat Grass	C1-3, C9-3
	Agrostis alba	Redtop	C14-3, C1-3, C9-3
	Aster sp.	Aster	C9-3, C1-3
	Caprifoliaceae sp.	Honey suckle	C9-3
	Carex sp.	Sedge	C7-3
	Cirsium sp.	Thistle	C1-3
	Cornus stolonitera	Dogwood	C7-3
	Elymus cinereus	Great basin wild rye	C14-3, C7-3
	Epilobium angustifolium	Fire weed	C14-3, C1-3, C9-3
	Gaillardia aristata	Blanket flower	C14-3
	Galium boreale	Northern Bedstraw	C14-3
	Heuchera parvifolia	Alumroot	C1-3
	Lonicera utahensis		C9-3
	Lupinus argenteus	Silvery Lupine	C9-3
	Mahonia repens	Oregon grape	C14-3, C7-3
	Pinus flexilis	Limber pine	C1-3
	Poa pratensis	Kentucky Bluegrass	C7-3,C14-3
	Poa sp.		C1-3
	Poa secunda		C7-3
	Populus tremuloides	Quaking Aspen	C14-3
	Ribes cereum	Squaw currant	C14-3
	Salix sp.	Shrub	C9-3
	Shepherdia canadensis	Bufflow Berry	C7-3
	Solidago missouriens	Goldenrod	C7-3
	Spiraea breviifolia		C1-3
	Symphoricarpos oreophilus	Mt. snowberry	C14-3
Control: German Gulch			
	Agropyron spicatum	Bluebunch Bheatgrass	B13-3
	Tragapogon aruncus	Goats beard	B13-3
	Aster sp.	Aster	C3-3
	Astragalus sp.	Vetch	C3-3
	Juinperus communis	Juniper	B13-3
	Physocarpus malvaceus	Nine bark	C3-3
	Poa sp	Bluegrass	C3-3
	Pseudotsuga menziesii	Douglas Fir	C3-3, B13-3
	Purshia tridentata	Antelope Bitter Brush	B13-3
	Rosa woodsii	Rose	C3-3
	Sagittaria latifolia	Arrow leaf Balsam Root	B13-3
	Stipa nelsonii	Needle grass	C3-3, B13-3
	Symphoricarpos oreophilus	Mt. Snowberry	C3-3, B13-3

Table A-2. Continued.			
Collection Area	Genus species	Common name	Site
Control: Gregson			
	Agropyron spicatum	Bluebunch wheatgrass	A3-3
	Agropyron caninum	Slender Wheat Grass	B3-B15-3
	Pseudotsuga menziesii	Douglas fir	B3-B15-3, A3-3
	Purshia tridentata	Antelope Bitter Brush	A3-3
	Sagittaria latifolia	Arrow Leaf Balsam Root	A3-3
	Symphoricarpos oreophilus	Mt. Snowberry	B3-B15-3
	Unknown Forb		B3-B15-3

Table A-3. Stem growth rates of trees sampled at HEP sites.				
SITE	TAXON	1992 MEAN ± S.D.	1991 MEAN ± S.D.	1990 MEAN ± S.D.
A-03-5	Limber Pine	4.5 ± 2.5	3.4 ± 1.5	4.5 ± 2.5
C-01-3	Limber Pine	7.3 ± 3.0	7.5 ± 3.6	9.2 ± 4.1
C-09-3	Limber Pine	6.7 ± 1.4	6.4 ± 1.3	5.8 ± 1.8
B-05-6	Aspen 1	1.3 ± 0.5	2.5 ± 1.9	2.8 ± 2.8
	Aspen 2	1.6 ± 1.0	2.1 ± 1.1	3.0 ± 2.1
	Aspen 3	2.1 ± 1.2	3.8 ± 2.3	5.1 ± 5.6
	Aspen 4	2.1 ± 1.8	2.9 ± 4.0	6.5 ± 13.2
C-14-3	Aspen 1	1.5 ± 0.7	1.2 ± 0.6	1.8 ± 0.9
	Aspen 2	1.4 ± 0.8	1.2 ± 0.6	1.2 ± 0.0
CC-03-3	Douglas Fir 1	0.6 ± 0.2	0.8 ± 0.2	0.9 ± 0.3
	Douglas Fir 2	2.1 ± 0.7	3.1 ± 1.0	3.3 ± 1.0
	Douglas Fir 3	2.1 ± 0.5	2.4 ± 0.6	2.4 ± 0.8
	Douglas Fir 4	0.8 ± 0.4	1.2 ± 0.5	1.2 ± 0.5
BB-13-3	Douglas Fir 1	2.7 ± 1.2	4.5 ± 3.1	4.0 ± 2.1
	Douglas Fir 2	2.2 ± 0.8	4.4 ± 1.5	3.8 ± 1.5
AA-03-3	Douglas Fir 1	1.1 ± 0.5	1.5 ± 0.5	2.4 ± 0.9
	Douglas Fir 2	1.2 ± 0.3	2.1 ± 0.6	2.3 ± 0.6
	Douglas Fir 3	1.9 ± 0.6	3.1 ± 1.2	2.8 ± 1.0
	Douglas Fir 4	2.8 ± 1.0	2.3 ± 0.7	3.7 ± 1.3

Table A-4. Plant tissue chemical analysis sample list.

Site	Sample
Upland Impacted Sites	
Stucky Ridge	
A-06-5	MB 1 = Rose sp.
	MB 2 = Western Wild Rye
A-10-5	MB 3 = Thistle
	MB 4 = Rabbit Brush
	MB 5 = Red Top
A-03-5	MB 6 = Knapweed and thistle
	MB 7 = Rabbit Brush
	MB 8 = Indian Rice Grass and Western Wild Rye
	MB 9 = Limber Pine needles
Smelter Hill	
B-16-6	MB 11 = *Grindelia squarrosa, Aster adscendens*
	MB 12 = Western Wild Rye
B-13-6	MB 14 = Forbs
	MB 15 = Western Wild Rye
B-11-6	MB 16 = *Chrysothannus viscidiflorus*
	MB 18 = Western Wild Rye and Carex
B-05-6	MB 20 = Quaking Aspen Leaves
	MB 21 = Fire Weed, Aster, False Solomon's Seal
	MB 23 = Redtop
B-03-6	MB 24 = Knapweed
	MB 25 = Rabbit Brush, Broom Snake weed
	MB 26 = Western Wild Rye, Bluegrass
	MB 27 = Limber Pine needles
Mt. Haggin	
C-09-3	MB 29 = Fire Weed, Aster, Lupine
	MB 30 = Red Top, Slender Wheat Grass
	MB 34 = Limber Pine needles
C-14-3	MB 35 = Forbs
	MB 36 = Oregon Grape, *Ribes lereun*, Mt. Snowberry
	MB 38 = Great Basin Wild Rye, Red Top, Bluegrass
	MB 40 = Aspen Leaves
C-07-3	MB 42 = *Carex, Poa* sp.. Western Wild Rye
	MB 44 = *Solidago missouriensis*, Fireweed
C-01-3	MB 45 = Aster, Fire weed. Thistle, *Heuchera*
	MB 46 = Slender Wheat Grass, *Poa* sp. Redtop.
	MB 49 = Limber Pine needles
Control Sites	
German Gulch Area	
CC-03-3	MB 50 = *Stipa nelsoni, Poa*
	MB 51 = Aster, Astragalus
	MB 52 = Nine Bark, *Rosa woodsii*, Mt. Snowberry
	MB 54 = Douglas Fir needles
BB-13-3	MB 56 = *Stipa nelsonii*, Blue bunch Wheat Grass
	MB 57 = MT. Snowberry, Antelope Bitter Brush
	MB 59 = Goats Beard, Arrow Leaf Balsam Root
	MB 60 = Douglas Fir needles
Gregson Area	
BB-03,15-3	MB 62 = Forbs
	MB 63 = Slender Wheat Grass
	MB 64 = Mt. Snow Berry
	MB 67 = Douglas Fir needles
AA-03-3	MB 68 = Arrow Leaf Balsam Root
	MB 69 = Blue Bunch Wheat Grass
	MB 70 = Antelope Bitter Brush
	MB 72 = Douglas Fir needles

Table A-5. Plant tissue metal concentrations.

Site I.D.	Sample I.D	Taxon	Zn	Cu	As	Cd	Pb
	Method Detection Limit		3.53	0.97	0.72	0.14	0.27
A-06	MB-01	shrubs	22.1	8.7	1.2	0.14	1.2
	MB-02	graminoids	55.4	8.0	<mdl	0.1	0.7
A-10	MB-03	forbs	218.4	199.7	30.7	0.8	14.1
	MB-04	shrubs	109.2	44.4	5.7	0.5	4.7
	MB-05	graminoids	57.8	23.2	5.0	0.2	1.3
	MB-06	forbs	36.9	34.0	4.8	<mdl	3.0
A-03	MB-07?	shrubs	63.0	17.0	<mdl	0.5	1.9
	MB-08	graminoids	22.1	9.8	2.1	<mdl	1.3
	MB-09	conifer (needles)	46.6	4.5	1.2	<mdl	2.4
B-16	MB-11	forbs	51.0	34.0	8.1	0.5	6.4
	MB-12	graminoids	28.2	6.9	1.9	0.2	2.0
B-13	MB-14	forbs	71.0	17.8	6.3	1.5	6.6
	MB-15	graminoids	27.7	7.8	1.5	0.2	2.1
B-11	MB-16	forbs	90.6	291	130.1	2.5	52.4
	MB-18	graminoids	74.5	18.3	5.6	0.5	2.0
B-05	MB-20	deciduous (leaves)	159.3	5.8	1.9	1.0	0.6
	MB-21	forbs	45.8	7.1	1.0	0.3	1.0
	MB-23	graminoids	95.0	11.1	3.4	1.5	0.6
B-03	MB-24	forbs	39.3	39.0	6.2	0.6	6.4
	MB-25	shrubs	74.5	39.3	5.0	0.8	6.2
	MB-26	graminoids	40.4	14.8	3.6	0.7	2.1
	MB-27	conifer (needles)	37.5	4.7	22.6	<mdl	1.3
C-09	MB-29	forbs	67.5	12.6	0.8	0.6	2.1
	MB-30	graminoids	60.5	13.4	1.5	0.6	1.5
	MB-34	conifer (needles)	22.5	3.5	3.3	<mdl	0.9
C-14	MB-35	forbs	68.9	13.0	3.6	0.4	2.4
	MB-36	shrubs	29.7	10.7	0.8	0.2	1.3
	MB-38	graminoids	33.2	5.4	<mdl	0.4	0.5
	MB-40	deciduous (leaves)	84.6	5.5	<mdl	0.6	0.7
C-07	MB-42	graminoids	58.9	6.3	<mdl	0.4	0.5
	MB-44	forbs	69.6	9.9	4.0	0.4	1.2
C-01	MB-45	forbs	35.8	9.2	2.6	1.0	1.6
	MB-46	graminoids	61.4	8.0	3.0	1.0	0.8
	MB-49	conifer (needles)	42.3	3.6	6.4	0.4	0.4
CC-03	MB-50	graminoids	31.7	4.9	1.4	0.4	0.4
	MB-51	shrubs	42.5	8.9	0.8	0.9	0.4
	MB-52	shrubs	32.7	7.3	0.4	0.4	0.8
CC-03	MB-54	conifer (needles)	21.0	3.8	80.5	0.3	1.0
BB-13	MB-55	conifer (ste	31.9	6.1	1.2	0.2	0.3
	MB-57	shrubs	16.9	3.3	<mdl	0.4	1.0
	MB-59	forbs	20.4	6.0	0.7	0.7	0.6
	MB-60	conifer (needles)	20.3	2.9	121.1	0.3	0.4

Table A-5. Continued.

BB-03	MB-62	forbs	89.0	9.2	2.2	2.0	2.5
	MB-63	graminoids	62.1	9.2	1.4	1.8	0.4
	MB-64	shrubs	64.5	6.6	0.5	0.4	1.0
	MB-67	conifer (needles)	17.5	2.7	91.8	<mdl	<mdl
AA-03	MB-68	forbs	25.3	8.7	0.7	<mdl	0.7
	MB-69	graminoids	52.7	6.6	1.5	0.5	0.3
	MB-70	shrubs	15.3	4.7	<mdl	0.3	1.7
	MB-72	conifer (needles)	24.7	4.0	92.0	0.2	1.2

Table A-6.

Statistical results of t-test and toxicity indice assignments for Stucky Ridge.					
Sample	Species-Endpoint.	Control	Data	t-statistic	Weighting Factor
A02-2	Alfalfa-Stem (mm)	36.2	36.0	0.4880	0
A02-2	Alfalfa-Root (mm)	79.5	43.0	0.0423	1
A02-2	Lettuce-Stem (mm)	32.9	39.0	0.6772	0
A02-2	Lettuce-Root (mm)	39.9	36.0	0.4161	0
A02-2	Wheat-Stem (mm)	156.0	174.0	0.6637	0
A02-2	Wheat-Root (mm)	162.1	82.0	0.0660	0
A02-2	Alfalfa-Root (g)	0.245	0.191	0.2958	0
A02-2	Alfalfa-Shoot (g)	0.326	0.306	0.4299	0
A02-2	Alfalfa-Total (g)	0.571	0.497	0.3609	0
A02-2	Lettuce-Root (g)	0.048	0.064	0.7178	0
A02-2	Lettuce-Shoot (g)	0.064	0.134	0.9486	0
A02-2	Lettuce-Total (g)	0.111	0.198	0.8981	0
A02-2	Wheat-Root (g)	1.628	1.023	0.1050	0
A02-2	Wheat-Shoot (g)	1.380	1.706	0.7660	0
A02-2	Wheat-Total (g)	3.008	2.729	0.3726	0
A02-2	Alfalfa-Germ. (%)	72.1	63.4	0.3217	0
A02-2	Lettuce-Germ. (%)	0.5	53.7	0.9983	0
A02-2	Wheat-Germ. (%)	70.4	75.8	0.7990	0
A03-2	Alfalfa-Stem (mm)	36.2	15.0	0.0082	2
A03-2	Alfalfa-Root (mm)	79.5	7.0	0.0008	4
A03-2	Lettuce-Stem (mm)	32.9	17.0	0.1196	0
A03-2	Lettuce-Root (mm)	39.9	14.0	0.0829	0
A03-2	Wheat-Stem (mm)	156.0	90.0	0.0649	0
A03-2	Wheat-Root (mm)	162.1	25.0	0.0067	4
A03-2	Alfalfa-Root (g)	0.245	0.014	0.0143	4
A03-2	Alfalfa-Shoot (g)	0.326	0.063	0.0149	4
A03-2	Alfalfa-Total (g)	0.571	0.077	0.0123	4
A03-2	Lettuce-Root (g)	0.048	0.001	0.0529	0
A03-2	Lettuce-Shoot (g)	0.064	0.006	0.0896	0
A03-2	Lettuce-Total (g)	0.111	0.007	0.0647	0
A03-2	Wheat-Root (g)	1.628	0.478	0.0110	2
A03-2	Wheat-Shoot (g)	1.380	0.692	0.0665	0
A03-2	Wheat-Total (g)	3.008	1.170	0.0203	2
A03-2	Alfalfa-Germ. (%)	72.1	41.6	0.0562	0
A03-2	Lettuce-Germ. (%)	0.5	14.2	0.7944	0
A03-2	Wheat-Germ. (%)	70.4	62.7	0.1224	0

Table A-6. Continued.

Stucky Ridge (continued).					
Sample	Species-Endpoint.	Control	Data	t-statistic	Weighting Factor
A06-2	Alfalfa-Stem (mm)	36.2	15.0	0.0082	2
A06-2	Alfalfa-Root (mm)	79.5	4.0	0.0005	4
A06-2	Lettuce-Stem (mm)	32.9	11.0	0.0546	0
A06-2	Lettuce-Root (mm)	39.9	2.0	0.0236	4
A06-2	Wheat-Stem (mm)	156.0	83.0	0.0478	1
A06-2	Wheat-Root (mm)	162.1	7.0	0.0030	4
A06-2	Alfalfa-Root (g)	0.245	0.026	0.0185	4
A06-2	Alfalfa-Shoot (g)	0.326	0.101	0.0299	2
A06-2	Alfalfa-Total (g)	0.571	0.127	0.0207	4
A06-2	Lettuce-Root (g)	0.048	0.002	0.0565	0
A06-2	Lettuce-Shoot (g)	0.064	0.020	0.1529	0
A06-2	Lettuce-Total (g)	0.111	0.022	0.0957	0
A06-2	Wheat-Root (g)	1.628	0.744	0.0360	2
A06-2	Wheat-Shoot (g)	1.380	0.909	0.1489	0
A06-2	Wheat-Total (g)	3.008	1.653	0.0618	0
A06-2	Alfalfa-Germ. (%)	72.1	46.1	0.0871	0
A06-2	Lettuce-Germ. (%)	0.5	33.2	0.9717	0
A06-2	Wheat-Germ. (%)	70.4	69.7	0.4614	0
A08-2	Alfalfa-Stem (mm)	36.2	32.0	0.3053	0
A08-2	Alfalfa-Root (mm)	79.5	57.0	0.1392	0
A08-2	Lettuce-Stem (mm)	32.9	23.0	0.2300	0
A08-2	Lettuce-Root (mm)	39.9	28.0	0.2590	0
A08-2	Wheat-Stem (mm)	156.0	154.0	0.4812	0
A08-2	Wheat-Root (mm)	162.1	135.0	0.3012	0
A08-2	Alfalfa-Root (g)	0.245	0.219	0.3981	0
A08-2	Alfalfa-Shoot (g)	0.326	0.403	0.7459	0
A08-2	Alfalfa-Total (g)	0.571	0.622	0.5962	0
A08-2	Lettuce-Root (g)	0.048	0.068	0.7632	0
A08-2	Lettuce-Shoot (g)	0.064	0.093	0.7576	0
A08-2	Lettuce-Total (g)	0.111	0.161	0.7695	0
A08-2	Wheat-Root (g)	1.628	1.982	0.7705	0
A08-2	Wheat-Shoot (g)	1.380	1.650	0.7265	0
A08-2	Wheat-Total (g)	3.008	3.632	0.7652	0
A08-2	Alfalfa-Germ. (%)	72.1	80.0	0.6627	0
A08-2	Lettuce-Germ. (%)	0.5	61.3	0.9995	0
A08-2	Wheat-Germ. (%)	70.4	80.0	0.9280	0

Table A-6. Continued.

Stucky Ridge (continued).					
Sample	Species-Endpoint.	Control	Data	t-statistic	Weighting Factor
A10-2	Alfalfa-Stem (mm)	36.2	7.0	0.0008	4
A10-2	Alfalfa-Root (mm)	79.5	4.0	0.0005	4
A10-2	Lettuce-Stem (mm)	32.9	4.0	0.0190	4
A10-2	Lettuce-Root (mm)	39.9	3.0	0.0264	4
A10-2	Wheat-Stem (mm)	156.0	36.0	0.0044	4
A10-2	Wheat-Root (mm)	162.1	4.0	0.0026	4
A10-2	Alfalfa-Root (g)	0.245	0.001	0.0107	4
A10-2	Alfalfa-Shoot (g)	0.326	0.002	0.0045	4
A10-2	Alfalfa-Total (g)	0.571	0.003	0.0055	4
A10-2	Lettuce-Root (g)	0.048	0.002	0.0565	0
A10-2	Lettuce-Shoot (g)	0.064	0.004	0.0826	0
A10-2	Lettuce-Total (g)	0.111	0.006	0.0630	0
A10-2	Wheat-Root (g)	1.628	0.593	0.0187	2
A10-2	Wheat-Shoot (g)	1.380	0.422	0.0203	2
A10-2	Wheat-Total (g)	3.008	1.015	0.0137	2
A10-2	Alfalfa-Germ. (%)	72.1	22.0	0.0062	2
A10-2	Lettuce-Germ. (%)	0.5	11.5	0.7467	0
A10-2	Wheat-Germ. (%)	70.4	78.5	0.8912	0

Table A-7.

Statistical results of t-test and toxicity indice assignments for Smelter Hill.					
Sample	Species-Endpoint	Control	Data	t-Statistic	Weighting Factor
B02-2	Alfalfa-Stem (mm)	36.2	19.0	0.0235	1
B02-2	Alfalfa-Root (mm)	79.5	11.0	0.0012	4
B02-2	Lettuce-Stem (mm)	32.9	20.0	0.1687	0
B02-2	Lettuce-Root (mm)	39.9	5.0	0.0330	4
B02-2	Wheat-Stem (mm)	156.0	96.0	0.0834	0
B02-2	Wheat-Root (mm)	162.1	44.0	0.0152	2
B02-2	Alfalfa-Root (g)	0.245	0.024	0.0177	4
B02-2	Alfalfa-Shoot (g)	0.326	0.123	0.0436	2
B02-2	Alfalfa-Total (g)	0.571	0.147	0.0253	2
B02-2	Lettuce-Root (g)	0.048	0.003	0.0603	0
B02-2	Lettuce-Shoot (g)	0.064	0.020	0.1529	0
B02-2	Lettuce-Total (g)	0.111	0.023	0.0982	0
B02-2	Wheat-Root (g)	1.628	0.871	0.0601	0
B02-2	Wheat-Shoot (g)	1.380	0.951	0.1710	0
B02-2	Wheat-Total (g)	3.008	1.822	0.0876	0
B02-2	Alfalfa-Germ. (%)	72.1	56.2	0.1990	0
B02-2	Lettuce-Germ. (%)	0.5	30.0	0.9583	0
B02-2	Wheat-Germ. (%)	70.4	77.1	0.8479	0
B03-2	Alfalfa-Stem (mm)	36.2	31.0	0.2650	0
B03-2	Alfalfa-Root (mm)	79.5	43.0	0.0423	1
B03-2	Lettuce-Stem (mm)	32.9	32.0	0.4738	0
B03-2	Lettuce-Root (mm)	39.9	43.0	0.5678	0
B03-2	Wheat-Stem (mm)	156.0	166.0	0.5929	0
B03-2	Wheat-Root (mm)	162.1	110.0	0.1602	0
B03-2	Alfalfa-Root (g)	0.245	0.147	0.1665	0
B03-2	Alfalfa-Shoot (g)	0.326	0.259	0.2801	0
B03-2	Alfalfa-Total (g)	0.571	0.406	0.2153	0
B03-2	Lettuce-Root (g)	0.048	0.051	0.5460	0
B03-2	Lettuce-Shoot (g)	0.064	0.102	0.8182	0
B03-2	Lettuce-Total (g)	0.111	0.153	0.7323	0
B03-2	Wheat-Root (g)	1.628	1.368	0.2923	0
B03-2	Wheat-Shoot (g)	1.380	1.779	0.8121	0
B03-2	Wheat-Total (g)	3.008	3.147	0.5643	0
B03-2	Alfalfa-Germ. (%)	72.1	77.079	0.6038	0
B03-2	Lettuce-Germ. (%)	0.5	46.146	0.9950	0
B03-2	Wheat-Germ. (%)	70.4	73.570	0.6898	0

Table A-7. Continued.

Smelter Hill (continued).					
Sample	Species-Endpoint.	Control	Data	t-statistic	Weighting Factor
B04-2	Alfalfa-Stem (mm)	36.2	16.0	0.0108	2
B04-2	Alfalfa-Root (mm)	79.5	6.0	0.0007	4
B04-2	Lettuce-Stem (mm)	32.9	10.0	0.0474	2
B04-2	Lettuce-Root (mm)	39.9	2.0	0.0236	4
B04-2	Wheat-Stem (mm)	156.0	43.0	0.0065	2
B04-2	Wheat-Root (mm)	162.1	9.0	0.0032	4
B04-2	Alfalfa-Root (g)	0.245	0.016	0.0149	4
B04-2	Alfalfa-Shoot (g)	0.326	0.083	0.0216	2
B04-2	Alfalfa-Total (g)	0.571	0.099	0.0155	4
B04-2	Lettuce-Root (g)	0.048	0.003	0.0603	0
B04-2	Lettuce-Shoot (g)	0.064	0.018	0.1423	0
B04-2	Lettuce-Total (g)	0.111	0.021	0.0934	0
B04-2	Wheat-Root (g)	1.628	0.324	0.0053	4
B04-2	Wheat-Shoot (g)	1.380	0.429	0.0209	2
B04-2	Wheat-Total (g)	3.008	0.753	0.0069	2
B04-2	Alfalfa-Germ. (%)	72.1	51.4	0.1370	0
B04-2	Lettuce-Germ. (%)	0.5	32.6	0.9694	0
B04-2	Wheat-Germ. (%)	70.4	69.7	0.4614	0
B05-2	Alfalfa-Stem (mm)	36.2	27.0	0.1363	0
B05-2	Alfalfa-Root (mm)	79.5	33.0	0.0155	2
B05-2	Lettuce-Stem (mm)	32.9	30.0	0.4144	0
B05-2	Lettuce-Root (mm)	39.9	23.0	0.1802	0
B05-2	Wheat-Stem (mm)	156.0	149.0	0.4346	0
B05-2	Wheat-Root (mm)	162.1	129.0	0.2626	0
B05-2	Alfalfa-Root (g)	0.245	0.155	0.1866	0
B05-2	Alfalfa-Shoot (g)	0.326	0.285	0.3600	0
B05-2	Alfalfa-Total (g)	0.571	0.440	0.2651	0
B05-2	Lettuce-Root (g)	0.048	0.020	0.1642	0
B05-2	Lettuce-Shoot (g)	0.064	0.045	0.3301	0
B05-2	Lettuce-Total (g)	0.111	0.065	0.2464	0
B05-2	Wheat-Root (g)	1.628	1.312	0.2536	0
B05-2	Wheat-Shoot (g)	1.380	1.416	0.5323	0
B05-2	Wheat-Total (g)	3.008	2.728	0.3722	0
B05-2	Alfalfa-Germ. (%)	72.1	80.0	0.6627	0
B05-2	Lettuce-Germ. (%)	0.5	33.8	0.9738	0
B05-2	Wheat-Germ. (%)	70.4	72.5	0.6320	0

Table A-7. Continued.

Smelter Hill (continued).					
Sample	Species-Endpoint.	Control	Data	t-statistic	Weighting Factor
B09-2	Alfalfa-Stem (mm)	36.2	10.0	0.0020	2
B09-2	Alfalfa-Root (mm)	79.5	2.0	0.0004	4
B09-2	Lettuce-Stem (mm)	32.9	14.0	0.0821	0
B09-2	Lettuce-Root (mm)	39.9	44.0	0.5892	0
B09-2	Wheat-Stem (mm)	156.0	48.0	0.0085	2
B09-2	Wheat-Root (mm)	162.1	6.0	0.0028	4
B09-2	Alfalfa-Root (g)	0.245	0.001	0.0107	4
B09-2	Alfalfa-Shoot (g)	0.326	0.008	0.0051	4
B09-2	Alfalfa-Total (g)	0.571	0.009	0.0059	4
B09-2	Lettuce-Root (g)	0.048	0.002	0.0565	0
B09-2	Lettuce-Shoot (g)	0.064	0.013	0.1181	0
B09-2	Lettuce-Total (g)	0.111	0.015	0.0801	0
B09-2	Wheat-Root (g)	1.628	0.661	0.0253	2
B09-2	Wheat-Shoot (g)	1.380	0.557	0.0376	2
B09-2	Wheat-Total (g)	3.008	1.218	0.0228	2
B09-2	Alfalfa-Germ. (%)	72.1	17.5	0.0035	4
B09-2	Lettuce-Germ. (%)	0.5	20.3	0.8809	0
B09-2	Wheat-Germ. (%)	70.4	62.7	0.1224	0
B11-2	Alfalfa-Stem (mm)	36.2	10.0	0.0020	2
B11-2	Alfalfa-Root (mm)	79.5	5.0	0.0006	4
B11-2	Lettuce-Stem (mm)	32.9	0.0	0.0098	4
B11-2	Lettuce-Root (mm)	39.9	0.0	0.0187	4
B11-2	Wheat-Stem (mm)	156.0	72.0	0.0287	2
B11-2	Wheat-Root (mm)	162.1	11.0	0.0036	4
B11-2	Alfalfa-Root (g)	0.245	0.040	0.0248	4
B11-2	Alfalfa-Shoot (g)	0.326	0.140	0.0577	0
B11-2	Alfalfa-Total (g)	0.571	0.180	0.0349	2
B11-2	Lettuce-Root (g)	0.048	0.000	0.0494	4
B11-2	Lettuce-Shoot (g)	0.064	0.000	0.0698	0
B11-2	Lettuce-Total (g)	0.111	0.000	0.0534	0
B11-2	Wheat-Root (g)	1.628	0.990	0.0935	0
B11-2	Wheat-Shoot (g)	1.380	0.752	0.0844	0
B11-2	Wheat-Total (g)	3.008	1.742	0.0745	0
B11-2	Alfalfa-Germ. (%)	72.1	72.5	0.5086	0
B11-2	Lettuce-Germ. (%)	0.5	0.0	0.4869	0
B11-2	Wheat-Germ. (%)	70.4	78.5	0.8912	0

Table A-7. Continued.

Smelter Hill (continued).					
Sample	Species-Endpoint.	Control	Data	t-statistic	Weighting Factor
B13-2	Alfalfa-Stem (mm)	36.2	12.0	0.0035	2
B13-2	Alfalfa-Root (mm)	79.5	9.0	0.0010	4
B13-2	Lettuce-Stem (mm)	32.9	24.0	0.2531	0
B13-2	Lettuce-Root (mm)	39.9	26.0	0.2254	0
B13-2	Wheat-Stem (mm)	156.0	44.0	0.0068	2
B13-2	Wheat-Root (mm)	162.1	24.0	0.0064	4
B13-2	Alfalfa-Root (g)	0.245	0.043	0.0264	4
B13-2	Alfalfa-Shoot (g)	0.326	0.105	0.0321	2
B13-2	Alfalfa-Total (g)	0.571	0.148	0.0255	2
B13-2	Lettuce-Root (g)	0.048	0.004	0.0644	0
B13-2	Lettuce-Shoot (g)	0.064	0.009	0.1011	0
B13-2	Lettuce-Total (g)	0.111	0.013	0.0760	0
B13-2	Wheat-Root (g)	1.628	0.673	0.0266	2
B13-2	Wheat-Shoot (g)	1.380	0.687	0.0652	0
B13-2	Wheat-Total (g)	3.008	1.360	0.0320	2
B13-2	Alfalfa-Germ. (%)	72.1	58.7	0.2379	0
B13-2	Lettuce-Germ. (%)	0.5	22.0	0.8994	0
B13-2	Wheat-Germ. (%)	70.4	69.7	0.4614	0
B16-2	Alfalfa-Stem (mm)	36.2	16.0	0.0108	2
B16-2	Alfalfa-Root (mm)	79.5	12.0	0.0014	4
B16-2	Lettuce-Stem (mm)	32.9	14.0	0.0821	0
B16-2	Lettuce-Root (mm)	39.9	8.0	0.0455	4
B16-2	Wheat-Stem (mm)	156.0	145.0	0.3980	0
B16-2	Wheat-Root (mm)	162.1	54.0	0.0230	2
B16-2	Alfalfa-Root (g)	0.245	0.060	0.0371	4
B16-2	Alfalfa-Shoot (g)	0.326	0.165	0.0850	0
B16-2	Alfalfa-Total (g)	0.571	0.225	0.0530	0
B16-2	Lettuce-Root (g)	0.048	0.016	0.1324	0
B16-2	Lettuce-Shoot (g)	0.064	0.033	0.2351	0
B16-2	Lettuce-Total (g)	0.111	0.049	0.1789	0
B16-2	Wheat-Root (g)	1.628	1.071	0.1236	0
B16-2	Wheat-Shoot (g)	1.380	1.636	0.7161	0
B16-2	Wheat-Total (g)	3.008	2.707	0.3630	0
B16-2	Alfalfa-Germ. (%)	72.1	56.8	0.2082	0
B16-2	Lettuce-Germ. (%)	0.5	36.3	0.9808	0
B16-2	Wheat-Germ. (%)	70.4	75.8	0.7990	0

Table A-8.

Statistical results of t-test and toxicity indice assignments for Mt. Haggin.					
Sample	Species-Endpoint	Control	Data	t-Statistic	Weighting Factor
C01-2	Alfalfa-Stem (mm)	36.2	13.0	0.0047	2
C01-2	Alfalfa-Root (mm)	79.5	12.0	0.0014	4
C01-2	Lettuce-Stem (mm)	32.9	6.0	0.0261	4
C01-2	Lettuce-Root (mm)	39.9	5.0	0.0330	4
C01-2	Wheat-Stem (mm)	156.0	104.0	0.1143	0
C01-2	Wheat-Root (mm)	162.1	33.0	0.0095	4
C01-2	Alfalfa-Root (g)	0.245	0.024	0.0177	4
C01-2	Alfalfa-Shoot (g)	0.326	0.076	0.0190	4
C01-2	Alfalfa-Total (g)	0.571	0.100	0.0157	4
C01-2	Lettuce-Root (g)	0.048	0.003	0.0603	0
C01-2	Lettuce-Shoot (g)	0.064	0.011	0.1093	0
C01-2	Lettuce-Total (g)	0.111	0.014	0.0780	0
C01-2	Wheat-Root (g)	1.628	1.477	0.3751	0
C01-2	Wheat-Shoot (g)	1.380	1.065	0.2418	0
C01-2	Wheat-Total (g)	3.008	2.542	0.2941	0
C01-2	Alfalfa-Germ. (%)	72.1	53.7	0.1656	0
C01-2	Lettuce-Germ. (%)	0.5	22.8	0.9074	0
C01-2	Wheat-Germ. (%)	70.4	74.7	0.7459	0
C03-2	Alfalfa-Stem (mm)	36.2	37.0	0.5359	0
C03-2	Alfalfa-Root (mm)	79.5	65.0	0.2408	0
C03-2	Lettuce-Stem (mm)	32.9	41.0	0.7287	0
C03-2	Lettuce-Root (mm)	39.9	50.0	0.7095	0
C03-2	Wheat-Stem (mm)	156.0	165.0	0.5838	0
C03-2	Wheat-Root (mm)	162.1	171.0	0.5679	0
C03-2	Alfalfa-Root (g)	0.245	0.404	0.9394	0
C03-2	Alfalfa-Shoot (g)	0.326	0.397	0.7292	0
C03-2	Alfalfa-Total (g)	0.571	0.801	0.8620	0
C03-2	Lettuce-Root (g)	0.048	0.054	0.5880	0
C03-2	Lettuce-Shoot (g)	0.064	0.086	0.7034	0
C03-2	Lettuce-Total (g)	0.111	0.140	0.6656	0
C03-2	Wheat-Root (g)	1.628	1.703	0.5624	0
C03-2	Wheat-Shoot (g)	1.380	1.568	0.6629	0
C03-2	Wheat-Total (g)	3.008	3.271	0.6202	0
C03-2	Alfalfa-Germ. (%)	72.1	78.5	0.6319	0
C03-2	Lettuce-Germ. (%)	0.5	35.1	0.9776	0
C03-2	Wheat-Germ. (%)	70.4	80.0	0.9280	0

Table A-8. Continued.

Mt. Haggin (continued).					
Sample	Species-Endpoint.	Control	Data	t-statistic	Weighting Factor
C05-2	Alfalfa-Stem (mm)	36.2	16.0	0.0108	2
C05-2	Alfalfa-Root (mm)	79.5	18.0	0.0029	4
C05-2	Lettuce-Stem (mm)	32.9	13.0	0.0719	0
C05-2	Lettuce-Root (mm)	39.9	7.0	0.0409	4
C05-2	Wheat-Stem (mm)	156.0	108.0	0.1326	0
C05-2	Wheat-Root (mm)	162.1	25.0	0.0067	4
C05-2	Alfalfa-Root (g)	0.245	0.013	0.0139	4
C05-2	Alfalfa-Shoot (g)	0.326	0.030	0.0079	4
C05-2	Alfalfa-Total (g)	0.571	0.043	0.0085	4
C05-2	Lettuce-Root (g)	0.048	0.033	0.3004	0
C05-2	Lettuce-Shoot (g)	0.064	0.085	0.6951	0
C05-2	Lettuce-Total (g)	0.111	0.118	0.5401	0
C05-2	Wheat-Root (g)	1.628	0.843	0.0538	0
C05-2	Wheat-Shoot (g)	1.380	0.992	0.1947	0
C05-2	Wheat-Total (g)	3.008	1.835	0.0899	0
C05-2	Alfalfa-Germ. (%)	72.1	26.6	0.0109	2
C05-2	Lettuce-Germ. (%)	0.5	63.4	0.9996	0
C05-2	Wheat-Germ. (%)	70.4	62.7	0.1224	0
C07-2	Alfalfa-Stem (mm)	36.2	16.0	0.0108	2
C07-2	Alfalfa-Root (mm)	79.5	16.0	0.0023	4
C07-2	Lettuce-Stem (mm)	32.9	20.0	0.1687	0
C07-2	Lettuce-Root (mm)	39.9	11.0	0.0619	0
C07-2	Wheat-Stem (mm)	156.0	98.0	0.0904	0
C07-2	Wheat-Root (mm)	162.1	29.0	0.0080	4
C07-2	Alfalfa-Root (g)	0.245	0.024	0.0177	4
C07-2	Alfalfa-Shoot (g)	0.326	0.067	0.0161	4
C07-2	Alfalfa-Total (g)	0.571	0.091	0.0143	4
C07-2	Lettuce-Root (g)	0.048	0.025	0.2107	0
C07-2	Lettuce-Shoot (g)	0.064	0.044	0.3216	0
C07-2	Lettuce-Total (g)	0.111	0.069	0.2653	0
C07-2	Wheat-Root (g)	1.628	1.344	0.2754	0
C07-2	Wheat-Shoot (g)	1.380	0.915	0.1519	0
C07-2	Wheat-Total (g)	3.008	2.259	0.1932	0
C07-2	Alfalfa-Germ. (%)	72.1	38.1	0.0394	1
C07-2	Lettuce-Germ. (%)	0.5	53.1	0.9982	0
C07-2	Wheat-Germ. (%)	70.4	78.5	0.8912	0

Table A-8. Continued.

Mt. Haggin (continued).					
Sample	Species-Endpoint.	Control	Data	t-statistic	Weighting Factor
C09-2	Alfalfa-Stem (mm)	36.2	16.00	0.0108	2
C09-2	Alfalfa-Root (mm)	79.5	11.0	0.0012	4
C09-2	Lettuce-Stem (mm)	32.9	13.0	0.0719	0
C09-2	Lettuce-Root (mm)	39.9	4.0	0.0295	4
C09-2	Wheat-Stem (mm)	156.0	105.0	0.1187	0
C09-2	Wheat-Root (mm)	162.1	15.0	0.0043	4
C09-2	Alfalfa-Root (g)	0.245	0.013	0.0139	4
C09-2	Alfalfa-Shoot (g)	0.326	0.031	0.0080	4
C09-2	Alfalfa-Total (g)	0.571	0.044	0.0086	4
C09-2	Lettuce-Root (g)	0.048	0.014	0.1184	0
C09-2	Lettuce-Shoot (g)	0.064	0.052	0.3922	0
C09-2	Lettuce-Total (g)	0.111	0.066	0.2510	0
C09-2	Wheat-Root (g)	1.628	0.783	0.0423	2
C09-2	Wheat-Shoot (g)	1.380	1.198	0.3424	0
C09-2	Wheat-Total (g)	3.008	1.981	0.1191	0
C09-2	Alfalfa-Germ. (%)	72.1	23.6	0.0076	2
C09-2	Lettuce-Germ. (%)	0.5	51.4	0.9976	0
C09-2	Wheat-Germ. (%)	70.4	74.7	0.7459	0
C12-2	Alfalfa-Stem (mm)	36.2	26.0	0.1127	0
C12-2	Alfalfa-Root (mm)	79.5	25.0	0.0065	2
C12-2	Lettuce-Stem (mm)	32.9	0.0	0.0098	4
C12-2	Lettuce-Root (mm)	39.9	0.0	0.0187	4
C12-2	Wheat-Stem (mm)	156.0	100.0	0.0979	0
C12-2	Wheat-Root (mm)	162.1	69.0	0.0412	2
C12-2	Alfalfa-Root (g)	0.245	0.124	0.1171	0
C12-2	Alfalfa-Shoot (g)	0.326	0.201	0.1413	0
C12-2	Alfalfa-Total (g)	0.571	0.325	0.1219	0
C12-2	Lettuce-Root (g)	0.048	0.000	0.0494	4
C12-2	Lettuce-Shoot (g)	0.064	0.000	0.0698	0
C12-2	Lettuce-Total (g)	0.111	0.000	0.0534	0
C12-2	Wheat-Root (g)	1.628	1.172	0.1706	0
C12-2	Wheat-Shoot (g)	1.380	0.946	0.1683	0
C12-2	Wheat-Total (g)	3.008	2.118	0.1525	0
C12-2	Alfalfa-Germ. (%)	72.1	67.2	0.3965	0
C12-2	Lettuce-Germ. (%)	0.5	0.0	0.4869	0
C12-2	Wheat-Germ. (%)	70.4	72.5	0.6320	0

Table A-8. Continued.

Mt. Haggin (continued).					
Sample	Species-Endpoint.	Control	Data	t-statistic	Weighting Factor
C14-2	Alfalfa-Stem (mm)	36.2	17.0	0.0141	2
C14-2	Alfalfa-Root (mm)	79.5	21.0	0.0041	2
C14-2	Lettuce-Stem (mm)	32.9	10.0	0.0474	2
C14-2	Lettuce-Root (mm)	39.9	8.0	0.0455	4
C14-2	Wheat-Stem (mm)	156.0	113.0	0.1585	0
C14-2	Wheat-Root (mm)	162.1	18.0	0.0049	4
C14-2	Alfalfa-Root (g)	0.245	0.097	0.0743	0
C14-2	Alfalfa-Shoot (g)	0.326	0.206	0.1509	0
C14-2	Alfalfa-Total (g)	0.571	0.303	0.1027	0
C14-2	Lettuce-Root (g)	0.048	0.015	0.1253	0
C14-2	Lettuce-Shoot (g)	0.064	0.033	0.2351	0
C14-2	Lettuce-Total (g)	0.111	0.048	0.1752	0
C14-2	Wheat-Root (g)	1.628	0.957	0.0830	0
C14-2	Wheat-Shoot (g)	1.380	1.213	0.3548	0
C14-2	Wheat-Total (g)	3.008	2.170	0.1667	0
C14-2	Alfalfa-Germ. (%)	72.1	75.8	0.5778	0
C14-2	Lettuce-Germ. (%)	0.5	44.4	0.9936	0
C14-2	Wheat-Germ. (%)	70.4	77.1	0.8479	0

Table A-9.

Statistical results of t-test and toxicity indice assignments for riparian data, impact samples. Assume equal variances between riparian reference and impact and pond samples.					
Sample	Species-Endpoint	Control	Data	t-Statistic	Weighting Factor
R04-2	Alfalfa-Stem (mm)	47.0	0.0	0.0062	4
R04-2	Alfalfa-Root (mm)	78.0	0.0	0.0047	4
R04-2	Lettuce-Stem (mm)	33.0	0.0	0.0042	4
R04-2	Lettuce-Root (mm)	30.0	0.0	0.0000	4
R04-2	Wheat-Stem (mm)	203.0	0.0	0.0067	4
R04-2	Wheat-Root (mm)	178.0	0.0	0.0022	4
R04-2	Alfalfa-Root (g)	0.373	0.000	0.0189	4
R04-2	Alfalfa-Shoot (g)	0.587	0.000	0.0029	4
R04-2	Alfalfa-Total (g)	0.960	0.000	0.0010	4
R04-2	Lettuce-Root (g)	0.052	0.000	0.0000	4
R04-2	Lettuce-Shoot (g)	0.089	0.000	0.0000	4
R04-2	Lettuce-Total (g)	0.141	0.000	0.0000	4
R04-2	Wheat-Root (g)	2.541	0.000	0.0303	4
R04-2	Wheat-Shoot (g)	1.946	0.000	0.0302	4
R04-2	Wheat-Total (g)	4.487	0.000	0.0298	4
R04-2	Alfalfa-Germ. (%)	84.3	0.0	0.0302	4
R04-2	Lettuce-Germ. (%)	43.3	0.0	0.0010	4
R04-2	Wheat-Germ. (%)	77.1	0.0	0.0756	0
R08-2	Alfalfa-Stem (mm)	47.0	0.000	0.0062	4
R08-2	Alfalfa-Root (mm)	78.0	0.000	0.0047	4
R08-2	Lettuce-Stem (mm)	33.0	0.000	0.0042	4
R08-2	Lettuce-Root (mm)	30.0	0.000	0.0000	4
R08-2	Wheat-Stem (mm)	203.0	23.000	0.0100	4
R08-2	Wheat-Root (mm)	178.0	0.000	0.0022	4
R08-2	Alfalfa-Root (g)	0.373	0.000	0.0189	4
R08-2	Alfalfa-Shoot (g)	0.587	0.000	0.0029	4
R08-2	Alfalfa-Total (g)	0.960	0.000	0.0010	4
R08-2	Lettuce-Root (g)	0.052	0.000	0.0000	4
R08-2	Lettuce-Shoot (g)	0.089	0.000	0.0000	4
R08-2	Lettuce-Total (g)	0.141	0.000	0.0000	4
R08-2	Wheat-Root (g)	2.541	0.000	0.0303	4
R08-2	Wheat-Shoot (g)	1.946	0.091	0.0344	4
R08-2	Wheat-Total (g)	4.487	0.091	0.0315	4
R08-2	Alfalfa-Germ. (%)	84.3	17.458	0.0543	0
R08-2	Lettuce-Germ. (%)	43.3	5.739	0.0017	4
R08-2	Wheat-Germ. (%)	77.1	27.972	0.1611	0

Table A-9. Continued.

Rriparian and Pond: equal variances (continued).					
Sample	Species-Endpoint	Control	Data	t-Statistic	Weighting Factor
R13-2	Alfalfa-Stem (mm)	47.0	12.000	0.0161	2
R13-2	Alfalfa-Root (mm)	78.0	3.000	0.0053	4
R13-2	Lettuce-Stem (mm)	33.0	11.000	0.0160	2
R13-2	Lettuce-Root (mm)	30.0	2.000	0.0000	4
R13-2	Wheat-Stem (mm)	203.0	37.000	0.0129	4
R13-2	Wheat-Root (mm)	178.0	4.000	0.0024	4
R13-2	Alfalfa-Root (g)	0.373	0.005	0.0197	4
R13-2	Alfalfa-Shoot (g)	0.587	0.050	0.0039	4
R13-2	Alfalfa-Total (g)	0.960	0.055	0.0012	4
R13-2	Lettuce-Root (g)	0.052	0.000	0.0000	4
R13-2	Lettuce-Shoot (g)	0.089	0.002	0.0000	4
R13-2	Lettuce-Total (g)	0.141	0.002	0.0000	4
R13-2	Wheat-Root (g)	2.541	0.842	0.0791	0
R13-2	Wheat-Shoot (g)	1.946	0.878	0.1139	0
R13-2	Wheat-Total (g)	4.487	1.720	0.0915	0
R13-2	Alfalfa-Germ. (%)	84.3	38.645	0.1163	0
R13-2	Lettuce-Germ. (%)	43.3	9.974	0.0026	4
R13-2	Wheat-Germ. (%)	77.1	62.028	0.3734	0
R14-2	Alfalfa-Stem (mm)	47.0	0.000	0.0062	4
R14-2	Alfalfa-Root (mm)	78.0	0.000	0.0047	4
R14-2	Lettuce-Stem (mm)	33.0	0.000	0.0042	4
R14-2	Lettuce-Root (mm)	30.0	0.000	0.0000	4
R14-2	Wheat-Stem (mm)	203.0	27.000	0.0107	4
R14-2	Wheat-Root (mm)	178.0	0.000	0.0022	4
R14-2	Alfalfa-Root (g)	0.373	0.000	0.0189	4
R14-2	Alfalfa-Shoot (g)	0.587	0.000	0.0029	4
R14-2	Alfalfa-Total (g)	0.960	0.000	0.0010	4
R14-2	Lettuce-Root (g)	0.052	0.000	0.0000	4
R14-2	Lettuce-Shoot (g)	0.089	0.000	0.0000	4
R14-2	Lettuce-Total (g)	0.141	0.000	0.0000	4
R14-2	Wheat-Root (g)	2.541	0.000	0.0303	4
R14-2	Wheat-Shoot (g)	1.946	0.000	0.0302	4
R14-2	Wheat-Total (g)	4.487	0.000	0.0298	4
R14-2	Alfalfa-Germ. (%)	84.3	0.000	0.0302	4
R14-2	Lettuce-Germ. (%)	43.3	0.000	0.0010	4
R14-2	Wheat-Germ. (%)	77.1	0.000	0.0756	0

Table A-9. Continued.

Rriparian and Pond: equal variances (continued).					
Sample	Species-Endpoint	Control	Data	t-Statistic	Weighting Factor
OP2-2	Alfalfa-Stem (mm)	47.0	4.0	0.0083	4
OP2-2	Alfalfa-Root (mm)	78.0	5.0	0.0059	4
OP2-2	Lettuce-Stem (mm)	33.0	8.0	0.0107	4
OP2-2	Lettuce-Root (mm)	30.0	13.0	0.0001	2
OP2-2	Wheat-Stem (mm)	203.0	15.0	0.0086	4
OP2-2	Wheat-Root (mm)	178.0	0.0	0.0022	4
OP2-2	Alfalfa-Root (g)	0.373	0.001	0.0190	4
OP2-2	Alfalfa-Shoot (g)	0.587	0.005	0.0030	4
OP2-2	Alfalfa-Total (g)	0.960	0.006	0.0010	4
OP2-2	Lettuce-Root (g)	0.052	0.006	0.0000	4
OP2-2	Lettuce-Shoot (g)	0.089	0.002	0.0000	4
OP2-2	Lettuce-Total (g)	0.141	0.008	0.0000	4
OP2-2	Wheat-Root (g)	2.541	0.000	0.0303	4
OP2-2	Wheat-Shoot (g)	1.946	0.086	0.0342	4
OP2-2	Wheat-Total (g)	4.487	0.1	0.0314	4
OP2-2	Alfalfa-Germ. (%)	84.3	10.0	0.0420	4
OP2-2	Lettuce-Germ. (%)	43.3	8.1	0.0021	4
OP2-2	Wheat-Germ. (%)	77.1	21.1	0.1339	0

Table A-10.

Statistical results of t-test and toxicity indice assignments for riparian data, impact samples. Assume unequal variances between riparian reference and impact and pond samples.					
Sample	Species-Endpoint	Control	Data	t-Statistic	Weighting Factor
R04-2	Alfalfa-Stem (mm)	47.0	0.0	0.0027	4
R04-2	Alfalfa-Root (mm)	78.0	0.00	0.0174	4
R04-2	Lettuce-Stem (mm)	33.0	0.0	0.0476	4
R04-2	Lettuce-Root (mm)	30.0	0.0	0.1004	0
R04-2	Wheat-Stem (mm)	203.0	0.0	0.0057	4
R04-2	Wheat-Root (mm)	178.0	0.0	0.0114	4
R04-2	Alfalfa-Root (g)	0.373	0.000	0.0153	4
R04-2	Alfalfa-Shoot (g)	0.587	0.000	0.0016	4
R04-2	Alfalfa-Total (g)	0.960	0.000	0.0012	4
R04-2	Lettuce-Root (g)	0.052	0.000	0.1076	0
R04-2	Lettuce-Shoot (g)	0.089	0.000	0.0497	4
R04-2	Lettuce-Total (g)	0.141	0.000	0.0578	0
R04-2	Wheat-Root (g)	2.541	0.000	0.0224	4
R04-2	Wheat-Shoot (g)	1.946	0.000	0.0205	4
R04-2	Wheat-Total (g)	4.487	0.000	0.0200	4
R04-2	Alfalfa-Germ. (%)	84.3	0.0	0.0112	4
R04-2	Lettuce-Germ. (%)	43.3	0.0	0.0003	4
R04-2	Wheat-Germ. (%)	77.1	0.0	0.0357	4
R08-2	Alfalfa-Stem (mm)	47.0	0.0	0.0027	4
R08-2	Alfalfa-Root (mm)	78.0	0.0	0.0174	4
R08-2	Lettuce-Stem (mm)	33.0	0.0	0.0476	4
R08-2	Lettuce-Root (mm)	30.0	0.0	0.1004	0
R08-2	Wheat-Stem (mm)	203.0	23.0	0.0085	4
R08-2	Wheat-Root (mm)	178.0	0.0	0.0114	4
R08-2	Alfalfa-Root (g)	0.373	0.000	0.0153	4
R08-2	Alfalfa-Shoot (g)	0.587	0.000	0.0016	4
R08-2	Alfalfa-Total (g)	0.960	0.000	0.0012	4
R08-2	Lettuce-Root (g)	0.052	0.000	0.1076	0
R08-2	Lettuce-Shoot (g)	0.089	0.000	0.0497	4
R08-2	Lettuce-Total (g)	0.141	0.000	0.0578	0
R08-2	Wheat-Root (g)	2.541	0.000	0.0224	4
R08-2	Wheat-Shoot (g)	1.946	0.091	0.0235	4
R08-2	Wheat-Total (g)	4.487	0.091	0.0213	4
R08-2	Alfalfa-Germ. (%)	84.3	17.5	0.0228	4
R08-2	Lettuce-Germ. (%)	43.3	5.7	0.0005	4
R08-2	Wheat-Germ. (%)	77.1	28.0	0.0976	0

Table A-10. Continued.

Rriparian and Pond: unequal variances (continued).					
Sample	Species-Endpoint	Control	Data	t-Statistic	Weighting Factor
R13-2	Alfalfa-Stem (mm)	47.0	12.0	0.0075	2
R13-2	Alfalfa-Root (mm)	78.0	3.0	0.0196	4
R13-2	Lettuce-Stem (mm)	33.0	11.0	0.1103	0
R13-2	Lettuce-Root (mm)	30.0	2.0	0.1132	0
R13-2	Wheat-Stem (mm)	203.0	37.0	0.0110	4
R13-2	Wheat-Root (mm)	178.0	4.0	0.0123	4
R13-2	Alfalfa-Root (g)	0.373	0.005	0.0159	4
R13-2	Alfalfa-Shoot (g)	0.587	0.050	0.0022	4
R13-2	Alfalfa-Total (g)	0.960	0.055	0.0015	4
R13-2	Lettuce-Root (g)	0.052	0.000	0.1076	0
R13-2	Lettuce-Shoot (g)	0.089	0.002	0.0525	0
R13-2	Lettuce-Total (g)	0.141	0.002	0.0597	0
R13-2	Wheat-Root (g)	2.541	0.842	0.0630	0
R13-2	Wheat-Shoot (g)	1.946	0.878	0.0889	0
R13-2	Wheat-Total (g)	4.487	1.720	0.0692	0
R13-2	Alfalfa-Germ. (%)	84.3	38.6	0.0609	0
R13-2	Lettuce-Germ. (%)	43.3	10.0	0.0007	4
R13-2	Wheat-Germ. (%)	77.1	62.0	0.3294	0
R14-2	Alfalfa-Stem (mm)	47.0	0.0	0.0027	4
R14-2	Alfalfa-Root (mm)	78.0	0.0	0.0174	4
R14-2	Lettuce-Stem (mm)	33.0	0.0	0.0476	4
R14-2	Lettuce-Root (mm)	30.0	0.0	0.1004	0
R14-2	Wheat-Stem (mm)	203.0	27.0	0.0091	4
R14-2	Wheat-Root (mm)	178.0	0.0	0.0114	4
R14-2	Alfalfa-Root (g)	0.373	0.000	0.0153	4
R14-2	Alfalfa-Shoot (g)	0.587	0.000	0.0016	4
R14-2	Alfalfa-Total (g)	0.960	0.000	0.0012	4
R14-2	Lettuce-Root (g)	0.052	0.000	0.1076	0
R14-2	Lettuce-Shoot (g)	0.089	0.000	0.0497	4
R14-2	Lettuce-Total (g)	0.141	0.000	0.0578	0
R14-2	Wheat-Root (g)	2.541	0.000	0.0224	4
R14-2	Wheat-Shoot (g)	1.946	0.000	0.0205	4
R14-2	Wheat-Total (g)	4.487	0.000	0.0200	4
R14-2	Alfalfa-Germ. (%)	84.3	0.0	0.0112	4
R14-2	Lettuce-Germ. (%)	43.3	0.0	0.0003	4
R14-2	Wheat-Germ. (%)	77.1	0.0	0.0357	4

Table A-10. Continued.

Rriparian and Pond: unequal variances (continued).					
Sample	Species-Endpoint	Control	Data	t-Statistic	Weighting Factor
OP2-2	Alfalfa-Stem (mm)	47.0	4.0	0.0037	4
OP2-2	Alfalfa-Root (mm)	78.0	5.0	0.0212	4
OP2-2	Lettuce-Stem (mm)	33.0	8.0	0.0874	0
OP2-2	Lettuce-Root (mm)	30.0	13.0	0.2174	0
OP2-2	Wheat-Stem (mm)	203.0	15.0	0.0073	4
OP2-2	Wheat-Root (mm)	178.0	0.0	0.0114	4
OP2-2	Alfalfa-Root (g)	0.373	0.001	0.0154	4
OP2-2	Alfalfa-Shoot (g)	0.587	0.005	0.0016	4
OP2-2	Alfalfa-Total (g)	0.960	0.006	0.0013	4
OP2-2	Lettuce-Root (g)	0.052	0.006	0.1315	0
OP2-2	Lettuce-Shoot (g)	0.089	0.002	0.0525	0
OP2-2	Lettuce-Total (g)	0.141	0.008	0.0659	0
OP2-2	Wheat-Root (g)	2.541	0.000	0.0224	4
OP2-2	Wheat-Shoot (g)	1.946	0.086	0.0233	4
OP2-2	Wheat-Total (g)	4.487	0.086	0.0212	4
OP2-2	Alfalfa-Germ. (%)	84.3	10.0	0.0166	4
OP2-2	Lettuce-Germ. (%)	43.3	8.1	0.0006	4
OP2-2	Wheat-Germ. (%)	77.1	21.1	0.0757	0

APPENDIX C

Assessment of Injury to Vegetation, Wildlife, and Wildlife Habitat - 1992 Data

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1.0 INTRODUCTION

The assessment of injury to terrestrial resources consists of the determination and quantification of injuries to soils, vegetation, and wildlife. During field sampling, these three resources were treated collectively because of their ecological inter-relationship. The assessment of injury to vegetation, wildlife, and wildlife habitat focuses on two main areas:

- Injury to upland vegetation and wildlife habitat in the vicinity of Anaconda

- Injury to riparian vegetation, wildlife, and wildlife habitat along Silver Bow Creek, from downstream of the Colorado Tailings to the Warm Springs Ponds, along the upper Clark Fork River, from the Warm Springs Ponds to Dear Lodge, and on the Opportunity Ponds.

This Appendix describes the results of the determination and quantification of injury to vegetation and wildlife habitat.

1.1 OBJECTIVES

The general objectives of the vegetation and wildlife assessments in upland and riparian areas were to investigate injury to plant communities, wildlife populations and wildlife habitat, and to quantify the extent of injury to these resources. Specific objectives were to:

- Identify baseline conditions (plant community composition and structure, and wildlife habitat quality) at upland and riparian control sites.

- Identify impacted conditions (plant community structure and composition, and wildlife habitat quality) at exposed upland and riparian sites.

- Determine injury by comparing conditions in comparable control areas with those in the impacted areas. This comparison tested the null hypothesis that no difference exists in vegetation community structure and wildlife habitat quality/quantity between impacted and control sites.

- Quantify injury to vegetation and wildlife resources by determining the spatial extent of injury and the magnitude of the injury responses.

2.0 METHODS

2.1 DELINEATION OF POTENTIALLY INJURED AREAS

The assessment of injury to vegetation and wildlife resources was limited to areas where *gross* injury was hypothesized to prevail. Based on field observations, discussions with local wildlife managers and phytoecologists, and information obtained from aerial and historical records and photographs, potential grossly injured areas were identified and delineated using the following criteria:

- Complete or virtual elimination of the indigenous major plant associations
- Little or no regeneration of the indigenous major plant associations
- Extensive top soil exposure and erosion associated with vegetation loss.

Three major upland areas were delineated as potentially being injured using the above criteria (Figure 2-1):

- Area A - the eastern portion of *Stucky Ridge* and the hills on the north side of Lost Creek (3.8 square miles in extent)

- Area B - the uplands surrounding and to the west and south of *Smelter Hill* (7.3 square miles in extent)

- Area C - the *Mount Haggin* uplands east of the Mill Creek highway (6.7 square miles in extent)

Thus, 17.8 square miles (46.1 square km) of upland vegetation and wildlife habitat were preliminarily delineated as being potentially grossly injured by releases of hazardous substances.

Potentially grossly injured riparian areas (slickens and tailings) on Opportunity Ponds and along Silver Bow Creek and the Clark Fork River between Warm Springs Ponds and Deer Lodge were delineated using the results of previous studies, aerial photographs and ground truthing visits. These studies showed that along the 34 miles of river, there are approximately 1,000 acres of devegetated slickens, and Opportunity Ponds consisted of approximately 5 square miles (3,400 acres) of virtually unvegetated tailings (see Appendix A: Assessment of Injury to Soils).

2.2 SAMPLE SITE LOCATION AND CONFIGURATION

The determination and quantification of injury to vegetation and wildlife resources in the upland and riparian areas is based on comparisons between designated impact and control

sample sites. The use of control areas aids injury determination (through "the establishment of a statistically significant difference in the biological response between samples from populations in the assessment area and in the control area" [43 CFR § 11.62 (f)(3)]) and quantification (through the identification of baseline services [43 CFR § 11.72 (d)]).

2.2.1 <u>Upland Sample Sites</u>

Upland impact sites were identified in Appendix A (Section 2.2.1). For the vegetation studies, only every other impact area sampling site was used. These are shown in Figure 2-1. The control sites for the Stucky Ridge, Smelter Hill and Mount Haggin impact sample sites were located in the German Gulch area (Opportunity and Burnt Mountain USGS 1:24,000 maps), based on its proximity (approximately 12 km south), its solid geology, and its similarity in elevation to the upland impact areas. Matched pair control sample sites were chosen in the German Gulch area for each of the impact area sample sites using the following procedure:

- The following environmental factors which influence potential vegetation and wildlife habitat distributions were characterized for each of the impact area sampling points: elevation, orientation of main drainage, slope steepness (flat, gentle, moderate, steep), slope aspect, and distance to a road open to traffic all year.

- Using the above characterizations, three matched control sample sites were identified for each of the impact sample sites. Each control site was selected so as to have similar slope steepness, aspect and drainage orientation, road proximity, and be within 200 feet of the elevation of its corresponding potential impact site.

- One of the three candidate control sites chosen for each impact sample site was randomly selected to serve as the actual control site. If it was found that the selected control site could not be used because of access difficulties, one of the remaining two potential sites was selected randomly.

The locations of the control sampling sites are shown in Figure 2-1.

Upland control Transect Pairs were identical to impact Transect Pairs except that their position was determined by the location of the paired sample point, and not the location of a UTM intersection point. Control transects were oriented to 345 and 255 degrees so that they matched the impact Transect Pair orientations. All sampling points along all transects were flagged and identified in the field with a unique number and letter combination.

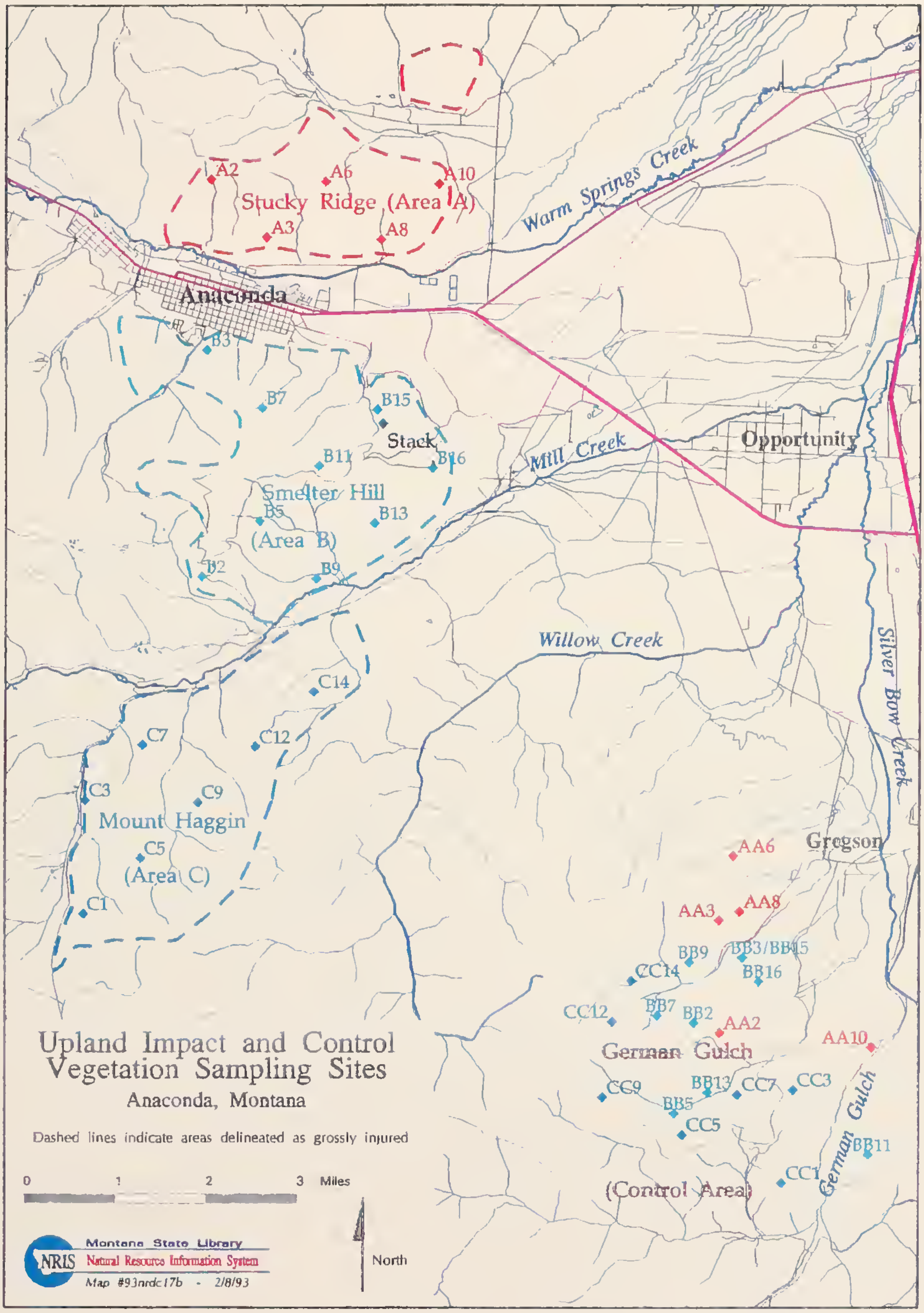

Figure 2-1. Delineations of Injured Upland Areas and Locations of Impact and Control Sampling Sites.

2.2.2 Riparian Sample Sites

Criteria used to classify potentially injured river reaches and select control reaches were based on vegetative characteristics and the environmental factors which influence riparian plant community structure and composition. These factors, hydrogeology, geomorphology, climate and land use patterns, are described in the following sections.

2.2.2.1 Hydrology and Geomorphology

The water regime is an important physical influence on the composition of riparian vegetation (Hansen et al., 1988; MRA, 1992). Riparian vegetation is sensitive to duration and frequency of flooding and drought, as well as to the position of the water table. The position and depth to the water table is related to three factors (Hansen et al., 1989):

- The stream gradient
- The valley bottom type (width and shape)
- Stream sinuosity and morphology.

Stream Gradient

High velocity, steep gradient streams typical of narrow v-shaped canyons, tend to have highly permeable soils and are among the driest of riparian sites (Hansen et al., 1989). Meandering, low velocity streams typically produce a diversity of landform types (e.g., stream bars, levees, riparian meadows) and have characteristic seasonal flooding. The range of soil moisture conditions associated with low velocity streams results in a wider range of mesic and hydric biological communities (Hansen et al., 1989).

Control reaches were selected such that average gradients differed by no more than 1.0% from the paired impact reach.

Valley Bottom Type

In southwest Montana there are three main valley bottom types (Hansen et al., 1989): v-shaped canyons, broad basins, and glaciated headwaters. Valley bottom type tends to correspond with stream order,[1] average flow, and valley bottom width. Control sites were chosen such that the valley bottom shapes were similar, particularly in terms of width. Differences in valley widths between test and control sites did not exceed 500 feet.

[1] Stream order refers to channel geometry. For example, channels that originate at a source are first order channels. Where two first order channels converge, they form a second order channel, etc.

Stream Sinuosity and Morphology

Sinuosity (how much the stream meanders) and channel morphology (e.g., braided, deeply incised with steep banks, channelized, eroded banks, etc.) are major determinants of riparian vegetation and were used in the selection of control streams to ensure similarity to corresponding impact reaches.

2.2.2.2 Climate

Although the narrow range of climatic conditions prevailing in river bottoms in southwest Montana is likely to have little effect on riparian vegetation communities, the composition and structure of adjacent upland plant communities are influenced by elevational and aspect influences on temperature, moisture availability, and seasonal distribution. Therefore, physical factors conditioning adjacent vegetation community composition were included, as appropriate, as criteria in selecting control streams.

Ambient temperature typically decreases with increasing elevation at a rate between 5 and 8° C/1,000 meters (Waring and Schlesinger, 1985). In southwest Montana, riparian sites with elevational differences greater than 1,000 feet, particularly at higher altitudes, are likely to support different adjacent plant communities. Elevation differences of less than 1,000 feet are unlikely to do so (P. Hansen, Montana Riparian Association, pers. comm.).

Valley orientation also affects annual precipitation, ambient temperature, and the seasonal distribution of precipitation. In southwest Montana, south-facing slopes are typically warmer and drier and support more xeric plant communities, such as shrublands and grasslands. North-facing slopes above approximately 5500 feet are cooler and moister and tend to be heavily forested with conifers (Pfister et al., 1983). Valley bottoms generally stay cooler than slopes with a southerly or westerly aspect, partially due to diurnal temperature fluctuation and cold air drainage down-valley. Additional orographic effects may produce cold-air pockets or drainages that result in a localized vegetation response (Peet, 1988).

Climate, elevation, and valley orientation as determinants of adjacent vegetation community types were used as criteria in selecting control streams. Control streams were chosen such that the elevation difference between each control and test site pair did not exceed 1,000 feet and the prevailing aspect of the control reach matched that of the assessment reach.

2.2.2.3 Land Use Patterns

Human land use of riparian areas in southwest Montana is, in part, a function of climate and topography. Low-lying, wide, alluvial valley bottoms may be suitable for agriculture (arable or pastoral), while steeper v-shaped canyons at higher elevations may be used as hunting

areas. Comparability in potential land use patterns was obtained by ensuring that the major topographical and climatic factors (see above) were similar in impact and control reaches.

Using the above criteria, Silver Bow Creek and the upper Clark Fork River had been previously subdivided into four topographically and ecologically distinct reaches during the course of work to determine injury to fish habitat and populations (see Lipton et al., 1995). The four reaches, defined by geomorphology and hydrology, are:

- Silver Bow Creek from below the Colorado Tailings in Butte to the upstream end of the Durant Canyon (Upper Silver Bow Creek)

- Silver Bow Creek from the upstream end of the Durant Canyon to the downstream end

- Silver Bow Creek from where it emerges from the Durant Canyon to its discharge into the Warm Springs Ponds

- The Clark Fork River from the Warm Springs Ponds discharge to Deer Lodge.

Reaches 1, 3, and 4 of the upper Clark Fork and Silver Bow Creek were sampled to assess injury to riparian vegetation and wildlife habitat. Due to time constraints, Reach 2 was not sampled. The location of sampling transects is shown in Figure 2-2. Since the existing patterns of drainage indicate that Opportunity Tailings Ponds have been superimposed on original riparian and wetland habitat, they were classified as a riparian impact area. Slickens and tailings in all impact areas were identified and mapped using aerial photographs, previous mapping studies, and field visits (see Appendix A).

Based on the criteria described above, three stream reaches were identified as control reaches: Divide Creek from the confluence of the North and East Forks was selected as the control for upper Silver Bow Creek; the Little Blackfoot River from Elliston to Avon was selected as the control reach for lower Silver Bow Creek; and Flint Creek from Sheryl to its confluence with the Clark Fork River was selected as the control for the upper Clark Fork River. Because of the extent and severity of the habitat changes imposed at Opportunity Ponds, no single suitable control site could be identified. Instead, Opportunity Pond sample sites were compared with all of the riparian control sites.

Transects were randomly located within each impact reach, but were confined to floodplain areas defined as slickens (developed areas devoid of vegetation, e.g., roads, parking lots, railroad, other structures, were classified as nonslickens). To select locations for transects, the length of each reach was measured, treating each side of the river separately. Six random numbers were then generated, each corresponding to a linear distance downstream on the west side of the river, continuing upstream on the east side. If a candidate transect did not cross a slickens, a new random number was generated.

Transects were oriented perpendicular to the river. Vegetation and wildlife sampling points along each transect were equally spaced at 10 meter intervals, beginning at the edge of the river. The width of the slickens determined the number of points sampled.

Six transects were established randomly in each control reach following the same methods used to position transects in the impact reaches. Transects were oriented perpendicular to the river, and Sample Points were established as described above. Transect length was determined as the mean slickens width in the corresponding impact reach, but transects did not extend beyond the floodplain.

On Opportunity Ponds, five UTM intersections were selected as described above (2.2.2) for vegetation and wildlife sampling in the upland areas. 500 meter north-south and east-west transects centered on a UTM intersection were sampled at 100 meter intervals. Table 2-1 identifies the locations of the sample transects on impact and control stream reaches.

2.3 SAMPLING VARIABLES AND MEASUREMENT METHODS

The following parameters were measured at sampling points:

- Single most prevalent cover type present (upland and riparian)
- Habitat layers present in most prevalent cover type (upland and riparian)
- Approximate height of each habitat layer in the most prevalent cover type (upland and riparian)
- % canopy closure of conifers in evergreen forest cover type (upland only)
- % canopy closure of plant species in the tree canopy, shrub midstory, and understory habitat layers (upland and riparian)
- % ground cover of downfall in evergreen forest cover type (upland only)
- Density of elk pellet groups (upland)
- Presence or absence of white-tailed deer browse (riparian only).

Each of these is defined and discussed below.

Figure 2-2. Location of Riparian Transects: Silver Bow Creek and the Clark Fork River.

Table 2–1
Locations of Riparian Control and Impact Transects

Name of River, Site #	Control/Impact	Longitude	Latitude
Divide Creek, #1	Control	112 44' 12"	45 46' 38"
Divide Creek, #2	Control	112 43' 38"	45 47' 08"
Divide Creek, #3	Control	112 43' 18"	45 47' 58"
Divide Creek, #4	Control	112 42' 16"	45 49' 50"
Divide Creek, #5	Control	112 42' 16"	45 50' 00"
Divide Creek, #6	Control	112 41' 54"	45 50' 30"
Flint Creek, #1	Control	113 11' 11"	46 34' 51"
Flint Creek, #2	Control	113 12' 23"	46 34' 08"
Flint Creek, #3	Control	113 10' 52"	46 35' 29"
Flint Creek, #4	Control	113 09' 32"	46 36' 51"
Flint Creek, #5	Control	113 09' 11"	46 37' 03"
Flint Creek, #6	Control	113 06' 02"	46 37' 51"
Little Blackfoot River, #1	Control	112 28' 11"	46 34' 20"
Little Blackfoot River, #2	Control	112 27' 21"	46 34' 11"
Little Blackfoot River, #3	Control	112 33' 04"	46 35' 30"
Little Blackfoot River, #4	Control	112 30' 28"	46 34' 28"
Little Blackfoot River, #5	Control	112 34' 16"	46 36' 00"
Little Blackfoot River, #6	Control	112 33' 58"	46 36' 00"
Clark Fork, #1	Impact	112 45' 37"	46 13' 20"
Clark Fork, #2	Impact	112 44' 38"	46 16' 09"
Clark Fork, #3	Impact	112 44' 20"	46 16' 36"
Clark Fork, #4	Impact	112 44' 16"	46 18' 19"
Clark Fork, #6	Impact	112 44' 12"	46 22' 41"
Opportunity Ponds #1	Impact	112 51' 06"	46 07' 49"
Opportunity Ponds #2	Impact	112 50' 16"	46 08' 21"
Opportunity Ponds #3	Impact	112 49' 39"	46 08' 54"
Opportunity Ponds #4	Impact	112 49' 39"	46 07' 49"
Opportunity Ponds #5	Impact	112 48' 43"	46 08' 21"
Silver Bow Creek, #1	Impact	112 36' 57"	46 00' 10"
Silver Bow Creek, #2	Impact	112 34' 56"	46 00' 01"
Silver Bow Creek, #3	Impact	112 40' 46"	46 00' 03"
Silver Bow Creek, #4	Impact	112 40' 20"	46 00' 21"
Silver Bow Creek, #5	Impact	112 43' 33"	46 00' 43"
Silver Bow Creek, #6	Impact	112 42' 50"	46 00' 20"
Silver Bow Creek, #7	Impact	112 47' 42"	46 02' 39"
Silver Bow Creek, #8	Impact	112 47' 39"	46 02' 35"
Silver Bow Creek, #9	Impact	112 48' 00"	46 05' 10"
Silver Bow Creek, #10	Impact	112 48' 01"	46 03' 56"
Silver Bow Creek, #11	Impact	112 48' 00"	46 06' 43"
Silver Bow Creek, #12	Impact	112 48' 03"	46 05' 51"

2.3.1 Single Most Prevalent Vegetative Cover Type

At each sampling point, the single most prevalent cover type within a 20 meter radius (upland) or 5 meter radius (riparian) was recorded. Cover types were identified as one of the following:

- Evergreen (conifer) forest - canopy closure of conifers at least 20 feet in height (upland and riparian)
- Deciduous forest - canopy closure of deciduous trees at least 20 feet in height (upland and riparian)
- Evergreen shrubland - canopy closure of conifers less than 20 feet in height (upland and riparian)
- Deciduous shrubland - canopy closure of shrubs and/or deciduous trees less than 20 feet in height (upland and riparian)
- Grassland and forbs - few or no trees or shrubs, canopy closure of grasses and/or forbs (upland and riparian)
- Bare ground - eroded topsoil with little or no vegetation present (upland and riparian)
- Slickens - bare ground composed of slickens or tailings (riparian)
- Hayfield - land cultivated for hay (riparian)
- Pasture - agricultural grassland grazed by livestock (riparian).

The most prevalent cover type was identified as that which would shade the greatest proportion of the ground surface if the sun were directly overhead.

2.3.2 Habitat Layers Present in Most Prevalent Cover Type

At each sampling point, the presence or absence of habitat layers in the cover type identified as most prevalent was recorded using the following criteria:

LAYER	PRESENCE CRITERIA
Tree canopy (TC)	Trees at least 20 feet in height shading at least 5% of the ground surface.
Tree bole (TB)	Diameter at breast height (dbh) at least 8 inches. Density at least 12 boles/ha (5/acre).
Shrub midstory (SM)	Vegetation between 20 inches and 20 feet in height shading at least 5% of ground surface.
Understory (US)	Vegetation up to 20 inches tall shading at least 5% of ground surface.
Terrestrial subsurface (TS)	*Unimpacted* (i.e., natural uneroded soil) soil layer covering at least 5% of area. Areas of severe topsoil erosion, slickens or tailings were excluded.
Surface water layer (SW)	Land surface-water interface and shallow water up to 10 inches deep present within 10 meter radius.
Water column layer (WC)	Layer of water more than 10 inches deep between the surface and the bottom of the water column within 10 meter radius.
Bottom of water column (BWC)	Water-terrestrial surface interface under more than 10 inches of water within 10 meter radius.

2.3.3 Approximate Height of Each Habitat Layer

At each Sampling Point, the average heights of each of the TC, SM and US layers within the most prevalent cover type were estimated visually (to the closest foot for the TC and SM layers and to the closest inch for the US layer).

2.3.4 Percent Canopy Closure in Evergreen Forest Cover Type

At each upland sampling point that fell in evergreen forest, the percent canopy closure of the tree canopy was estimated visually.

2.3.5 Percent Canopy Closure of Plant Species within Habitat Layers in Each Cover Type

At each sampling point, the percent canopy closure of tree, shrub, grass and forb species within each habitat layer was measured along 10 meter transects using the line intercept method.

2.3.6 Percent Groundfall Cover in Evergreen Forest Cover Type

At each upland sampling point in evergreen forest, the percent groundfall (downed timber) was measured along a 10 meter transect using the line intercept method. Groundfall is defined as dead woody material greater than 3 inches in diameter (including standing stumps).

2.3.7 Elk Pellet Group Densities (Upland Sites)

An elk pellet group was defined as five or more pellets separated from a similar group by at least 12 inches. At each sample point the numbers of such groups were recorded within one meter either side of a 10 meter transect.

2.3.8 Presence of White-Tailed Deer Browse (Riparian Sites)

At each riparian sample point the presence or absence of white-tailed deer browse within a 5 meter radius was recorded. Table 2-2 lists classifications of browse species in the northern Rocky Mountains. Plants classified as "poor" were not considered palatable to white-tailed deer and, therefore, not considered browse species.

The parameters listed above were measured by a team of two observers walking each transect. At each pre-flagged Sampling Point along those transects, measurements of the above parameters were made using two methods:

2.3.9 Visual Estimation

At each sample point the following parameters were estimated visually:

- The single most prevalent vegetative cover type
- The presence of habitat layers in the above cover type
- The average height of each habitat layer
- The percent canopy closure in evergreen forest (upland only)
- The presence of white-tailed deer browse.

Table 2-2
Palatability of White-Tailed Deer Browse Species in the Northern Rocky Mountains

Rating	Species	Common Name
Excellent	*Cornus stolonifera*	Red osier dogwood
	Thuja plicata	Western redcedar
	Ceanothus sanguineus	Redstem ceanothus
Good	*Amelanchier alnifolia*	Serviceberry
	Acer galbrum	Maple
	Pachistima mrysinites	Pachistima
	Salix sp.	Willow
	Arctostaphylos uva-ursi	Kinnikinnick
	Prunus virginiana	Chokecherry
	Pseudotsuga menziesii	Douglas fir
	Berberis repens	Oregon grape
	Vaccinium membranaceum	Huckleberry
	Rhamnus purshiana	Cascara
	Taxus brevifolia	Western yew
Fair	*Abies grandis*	Grand fir
	Crataegus sp.	Hawthorn
	Pinus ponderosa	Ponderosa pine
	Rosa sp.	Rose
	Pinus monticola	White pine
	Spiraea beutifolia	Spiraea
Poor	*Alnus sp.*	Alder
	Populus trichocarpa	Cottonwood
	Sambucus racemosa	Elderberry
	Tsuga heterophylla	Hemlock
	Lonicera spp.	Honeysuckle
	Pinus contorta	Lodgepole pine
	Menziesia ferruginea	Menziesia
	Physocarpus malvaceus	Ninebark
	Holodiscus discolor	Oceanspray
	Rubus parviflorus	Thimbleberry
	Symphoricarpos albus	Snowberry
	Philadelphus lewisii	Syringa
	Larix occidentalis	Western larch

Source: Jageman, 1984, modified from Pengelly, 1961.

2.3.10 Line Intercepts

At each sampling point the percent canopy closure of tree, shrub, forb, grass species, plant litter, rock, slickens and bare ground, and the numbers of elk pellet groups in each habitat layer, were measured using line intercepts (Hays et al., 1981, Gysel and Lyon, 1980). A 10 meter tape measure was laid on the ground oriented either 345 or 255 degrees (upland) or perpendicular to the stream (riparian) with the zero point at the pre-flagged Sampling Point position. The observer walked each transect, recording the points (to the nearest cm) where the shadows of plants, ledge of rock, bare ground, etc. would intersect the tape if the sun was vertically overhead and the tape just below the ground surface. For each plant that intersected the tape, the observer also recorded the species and the habitat layer in which it occurred. Where upland line intercepts were established in conifer forests, percent groundfall cover was recorded also. All measurements were recorded on specially designed Field Recording Forms.

2.4 VEGETATION INJURY DETERMINATION METHODS

Injury to vegetation communities was determined by statistically comparing impact and control areas for the following variables: proportional representation of each vegetative cover type; proportional representation of each habitat layer; proportional representation of number of habitat layers; and line transect cover measurements for individual plant species and bare ground.[2] Statistical comparisons were then made between impact and control sites in the three upland and four riparian impact areas: Stucky Ridge (Area A); Smelter Hill (Area B); Mount Haggin (Area C); upper Silver Bow Creek; lower Silver Bow Creek; the upper Clark Fork River; and the Opportunity Ponds.

2.5 VEGETATION INJURY QUANTIFICATION METHODS

The aerial extent of injured plant communities was initially determined using the mapping methodology described in Section 2.1. The results of the vegetation injury assessment were then used to test the validity of the initial delineation of injured vegetation. The spatial extent of injury was calculated to be the sum of those areas that were determined to have been injured.

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[2] In calculating proportional representations, if five of the ten sampling points in a transect or transect pair comprised evergreen forest cover type, the proportional representation of that cover type for that site was 0.5.

2.6 WILDLIFE INJURY DETERMINATION AND QUANTIFICATION METHODS

Two methods of determining and quantifying injury to wildlife were used.

- Determination of injury to wildlife habitat using habitat evaluation procedure (HEP) models [43 CFR § 11.71 (1)(8)]
- Population surveys of selected organisms (indicator species [43 CFR § 11.63 (f)(4)(ii)(A)]) at impact and control study sites.

2.6.1 HEP Models

HEP models are based on the relationship between the ecological features of an area and its ability to provide habitat for wildlife. Areas that provide features that satisfy all of a species' habitat requirements (i.e., high quality habitat) are likely to support greater population densities than areas deficient in those features (i.e., poor quality habitat) (Ricklefs, 1979). In HEP models, the important features of an area of habitat that influence its suitability for the model species are identified, and relationships that describe the availability of those features and the suitability of the habitat are established. HEP models provide relative indices of the potential carrying capacity of an area.

The selection of HEP models for this injury assessment was based on the types of habitats that were determined to have potentially been impacted. Initial field observations, together with discussions with local ecologists and wildlife managers, indicated that the major wildlife habitat types potentially injured are upland conifer forest and riparian shrub and forest habitats.

Comparison with adjacent upland areas suggested that the upland conifer forests potentially impacted by hazardous substances comprise two main plant associations: conifer forest (i.e., land under a canopy of Douglas fir (*Pseudotsuga menziesii*) or lodgepole pine (*Pinus contorta*)); and montane meadow and forest edge (i.e., grasslands interspersed among forest). Determination of injury to the forest habitat type was performed using marten (*Martes americana*) as an indicator species [43 CFR § 11.71 (1)(i)], while injury to the forest-edge and grassland habitat was determined using elk (*Cervus elaphus*) as an indicator species. White-tailed deer (*Oedicoileus virginianus*) was the indicator species chosen for the impacted riparian forest/shrub habitat.

2.6.1.1 Marten

Marten are primarily arboreal mammals and are confined in Montana to forested areas, particularly spruce-fir forests (Koehler and Hornocker, 1977; Hawley and Newby, 1957; Weckwerth and Hawley, 1962) or Douglas fir and lodgepole pine stands (Fager, 1992). Marten have been sighted recently in the German Gulch control area (M. Frisina, Montana Department of Fish, Wildlife, and Parks, pers comm.). A HEP model for marten winter habitat has been published by U.S. Fish and Wildlife (Allen, 1984 and Allen *pers comm.*) for use in the boreal forest biome and Rocky mountain forests of the western United States.

The model quantifies the suitability of an area for marten winter habitat using four variables:

- V1 - Percent tree canopy closure. Only forested areas are considered suitable marten habitat.
- V2 - Percent of canopy comprised of fir or spruce. Conifer forests are preferred to deciduous forests. Since Douglas fir and lodgepole pine are also used by marten in southwest Montana (Fager, 1992), these species were included with spruce and fir.
- V3 - The successional stage of the forest stand. Marten prefer mature or old growth stands to earlier successional stages (Koehler and Hornocker, 1977).
- V4 - Percent of ground surface covered by fallen timber > 3 inches in diameter. This parameter serves as a proxy for the availability of the marten's rodent prey (Allen, 1984).

Suitability index (SI) values are calculated for each variable (0 = poor habitat; 1 = optimum habitat) and an overall habitat suitability index (HSI) value calculated by $(V1 \times V2 \times V3 \times V4)^{1/2}$.

2.6.1.2 Elk

Because no suitable model with which to determine injury to wildlife habitat in the forest-edge and grasslands was available, a new model was developed. The indicator species chosen was elk. The model (describing winter habitat suitability) was developed with the participation of research ecologists and local wildlife managers with experience with the species in southwest Montana. The model was written and reviewed with the participation of the University of Montana, U.S. Forest Service, U.S. Fish and Wildlife Service, and the Montana Department of Fish, Wildlife and Parks. A copy of the final model is included as Attachment A.

This elk model is applicable to assessing the suitability of winter habitat in southwestern Montana and is based on three variables:

- The availability and quality of cover (no distinction is made between hiding and thermal cover) = HEc.

- The availability and quality of food = HEf.

- Freedom from human disturbance. Lyon (1983) established a numerical relationship between human disturbance (road density) and elk habitat utilization in western Montana. The possible effects of such disturbance were controlled for in this investigation by including distance to roads as a normalization factor when choosing control areas.

HEc and HEf are combined in the model in an overall habitat effectiveness (HE) variable.

HEc was calculated by estimating the proportional representation of the cover categories identified in the model (> 50% canopy closure; 31-50% canopy closure; 10-30% canopy closure; < 10% canopy closure) within a 1-km radius of the intersection of each transect pair. This was carried out by tracing cover category distributions from aerial photographs onto clear acetate overlays and estimating proportional representation using squared paper. These proportions were then multiplied by cover category suitability indices (> 50% canopy closure = 1.0; 31-50% canopy closure = 0.8; 10-30% canopy closure = 0.4; < 10% canopy closure = 0.1) and summed to give an overall HEc for each site.

HEf values for each canopy closure class were obtained by categorizing the palatability of plant species recorded along the line transects as "most valuable, less valuable, or least valuable" (Table 2-3). Litter, downed timber, rock and bare ground was categorized as "nonforage" and assigned a value of 0. The mean percent cover of each palatability category along the line transects was then measured for each canopy closure class. The forage suitability graph presented in the elk model was then utilized to provide an HEf value for each canopy closure class at each sample site. HE was then obtained for each site from $(HEc \times HEf)^{1/2}$.

2.6.1.3 White-Tailed Deer

Field observations and studies performed by MRA (1992) indicated that the riparian wildlife habitat affected most by the deposition of slickens along Silver Bow Creek and the Clark Fork River is riparian shrub and forest. The indicator species chosen to assess injury to these riparian habitats was white-tailed deer. Four HEP models have been published for assessing white-tailed deer winter habitat suitability in the Gulf of Mexico and the South Atlantic Coastal Plains (Short, 1986). Model number four was modified for use in evaluating winter

Table 2-3
Elk Forage Species and Their Palatability Ratings

Plant Species		Palatability Rating*
Trees and Shrubs		
Aspen	*Populus tremuloides*	V1
Bitterbrush	*Purshia tridentata*	V1
Chokecherry	*Prunus virginiana*	V1
Serviceberry	*Amelanchier alnifolium*	V1
Snowberry	*Symphoricarpos albus*	V1
Dogwood	*Cornus stolonifera*	V2
Douglas fir	*Pseudotsuga menziessi*	V2
Elder	*Sambucus racemosa*	V2
Horsebrush	*Tertradymia canescens*	V2
Oregon grape	*Mahonia repens*	V2
Rabbit brush	*Chrysothamnus nauseosus*	V2
Willow	*Salix spp.*	V2
Alder	*Alnus spp.*	V3
Bearberry	*Arctostaphylos uva-ursi*	V3
Blue huckleberry	*Vaccinium globulare*	V3
Common juniper	*Juniperus communis*	V3
Current	*Ribes sp.*	V3
Fringed sagewort	*Artemesia frigida*	V3
Grouseberry	*Vaccinium scoparium*	V3
Lodgepole pine	*Pinus contorta*	V3
Soapberry	*Shepherdia canadensis*	V3
Rocky Mountain juniper	*Juniperus scopulorum*	V3
Rose	*Rosa sp.*	V3
Forbs		
Lupine sp.	*Lupinus sp.*	V1
Mountain bells	*Mertensia sp.*	V1
Arnica	*Arnica cordifolia*	V2
Aster sp.	*Aster sp.*	V2
Balsamroot	*Balsomorhiza sagitata*	V2
Buckwheat	*Erigonum umbellatum*	V2
Dandelion	*Taraxacum sp.*	V2
Fireweed	*Epilobium angustifolium*	V2
Pea sp.	*Lathyrus sp.*	V2
Phlox sp.	*Phlox sp.*	V2
Strawberry	*Fragaria vesca*	V2

Table 2-3 (cont.)
Elk Forage Species and Their Palatability Ratings

Plant Species		Palatability Rating*
Forbs		
Twinberry	*Lonicera involucrata*	V2
Vetch sp.	*Astragalus sp.*	V2
Bedstraw	*Gallium boreale*	V3
Cerastium	*Cerastium sp.*	V3
Columbine	*Aquilegia flavescens*	V3
Cow parsnip	*Heracleum lanatum*	V3
Evening primrose	*Oenothera strigosa*	V3
Field thistle	*Cirsium arvense*	V3
Geranium	*Geranium sp.*	V3
Golden rod	*Solidago sp.*	V3
Iris	*Iris sp.*	V3
Knapweed	*Centaurea maculosa*	V3
Penstemon	*Penstemon sp.*	V3
Potentilla	*Potentilla glandulosa*	V3
Prickly pear	*Opuntia fragilis*	V3
Sandwort	*Arenaria sp.*	V3
Twinflower	*Linneae borealis*	V3
Typha	*Typha latifolia*	V3
Yarrow	*Achillea millefolium*	V3
Grasses		
Bluebunch wheatgrass	*Agropyron spicatum*	V1
Bluejoint reedgrass	*Calamagrostis canadensis*	V1
Fescue sp.	*Festuca sp.*	V1
Grass sp.		V1
Idaho fescue	*Festuca idahoensis*	V1
Kentucky blue grass	*Poa pratensis*	V1
Needle and thread	*Stipa comata*	V1
Timothy grass	*Phleum sp.*	V1
Bentgrass sp.	*Agrostis sp.*	V2
Blue grass sp.	*Poa sp.*	V2
Brome sp.	*Bromus sp.*	V2
Hairgrass	*Deschampsia cespitosa*	V2
Horsetail	*Equisetum sp.*	V2
Junegrass	*Koeleria cristata*	V2

Table 2-3 (cont.)
Elk Forage Species and Their Palatability Ratings

Plant Species		Palatability Rating*
Pine grass	*Calamagrostis rubescens*	V2
Sedge sp.	*Carex sp.*	V2
Baltic rush	*Juncus balticus*	V3
Cheat grass	*Bromus tectorum*	V3
Great basin wildrye	*Elymus cinerea*	V3

* Palatability ratings based on: Kufeld, 1973; Thomas and Toweill, 1982; Mueggler and Stewart, 1980; Mt. Haggin elk feces analyses (Frisina, *in prep.*); D. Strickland and M. Frisina *pers comm.*

V1 = most valuable forage; V2 = less valuable; V3 = least valuable (i.e., eaten when little or no other forage available).

habitat for white-tailed deer in Montana by incorporating preferred browse species in the northern Rocky Mountains (see Table 2-2).

The white-tailed deer model used in this assessment utilizes four variables:

- *Water Availability.* Free water must be available within 1.6 km of the habitat block being evaluated.
- *Habitat Block Area.* The habitat block being evaluated must be at least 40 ha in area.
- *Cover Availability.* Overstory or midstory cover must provide protective or thermal cover on at least 20% of the area being evaluated.
- *Forage Availability.* A sample site is categorized as either providing suitable white-tailed deer forage (see Table 2-2) or not doing so.

Because the habitat being evaluated is riparian, water was in close proximity to all impact and control areas and was not addressed specifically. Similarly, the areas being evaluated (impact and control reaches) are much greater in extent than 40 ha and this variable was not considered further.

2.6.1.4 Faunal Diversity

A fourth model, the Layers of Habitat Model (Short, 1984), was applied in both the upland and riparian areas of investigation. This model evaluates the potential of an area to support diverse wildlife populations using the relationship between species diversity in an area and the vertical heterogeneity of the habitat available. Habitats that are structurally complex (i.e., which have many habitat layers) generally support a more diverse fauna than structurally simple habitats, as has been shown for birds (Cody, 1975; MacArthur and MacArthur, 1961), reptiles (Pianka, 1967), fish (Tonn and Magnuson, 1982), and molluscs (Harman, 1972). In this assessment, the results of the Layers of Habitat Model were combined with information about the layers requirements of individual species to classify them into vegetation layer "guilds," i.e., groups of species whose niche spaces occur in the same vegetation layers or groups of vegetation layers (Short, 1984). This allows the identification of species which are likely to have been lost as a result of the removal of habitat layers.

Unimpacted conifer and riparian forest of the type found in southwest Montana has up to five vertical layers: Tree Canopy; Tree Bole; Shrub Midstory; Understory and Terrestrial subsurface. All of these layers provide foraging, cover and breeding niches for wildlife species. Consequently, loss of any of these layers may result in a reduced faunal diversity.

The Layers of Habitat Model quantifies the relationship between vertical heterogeneity and habitat provision for wildlife by calculating a Habitat Suitability Index (HSI). The HSI is a ratio in which the numerator is the number and extent of layers (i.e., the habitat vertical complexity) observed at a site, while the denominator is the number and extent of layers potentially present in optimum habitat. Thus, the HSI is an evaluation of the site's capacity to support a diversity of wildlife populations, relative to optimum conditions.

For the purposes of this assessment it was assumed that "optimum habitat" was the baseline habitat observed at the control sites. The control sites selected do not support pristine habitat (they have been, or are being, logged, cultivated and/or grazed by domestic stock). However, these conditions represent those that would be found at the impact sites in the absence of hazardous substance releases.

2.6.2 Riparian Bird Surveys

Two surveys of selected riparian bird species (common merganser, belted kingfisher, great blue heron, dipper and spotted sandpiper) were carried out on the 7-km reach of Silver Bow Creek between the downstream end of Durant Canyon and Warm Springs Ponds between the 28th and 29th of June 1992. These species were chosen because of their conspicuousness and the relative ease with which they can be censused. Two similar surveys were also carried out over the same time period on a 5-km stretch of the reach of the Little Blackfoot River which was identified as the control for the Silver Bow Creek reach. On each of these surveys the

study reach of the river was walked by an observer experienced in surveying riparian bird populations and the numbers of individual birds encountered were recorded.

2.7 STATISTICAL METHODS

Data were entered into computer spreadsheets and analyzed using two main statistical software programs, SPSS/PC (SPSS/PC, 1990) and RT (a program for randomization testing (Manly, 1991)). One-sample Randomization Tests were utilized to compare upland control and impact areas; Two-sample Randomization Tests were used to compare riparian sites. In addition, Blocked One-way Analyses of Variance were also used to compare sites. Where multiple comparisons were performed, the Bonferroni procedure (using an initial protection level of 0.1) was made to reduce the risk of Type-I errors by setting stringent significance levels. This procedure resulted in some comparisons being carried out at $\alpha = 0.033$. The sample size in each statistical test was determined by the number of sampling sites in each area.

3.0 RESULTS

3.1 UPLAND VEGETATION

Cover Types

Figures 3-1 through 3-3 show the proportional representations of vegetation cover types in impact areas A, B, and C, in comparison to those in their control areas. The main differences between impact and control areas identified by these figures are that:

- Whereas impact area A (Stucky Ridge) is predominantly bare ground (exposed, eroding topsoil) with lesser representation of grassland and deciduous shrub, baseline conditions at the matching control sites consist principally of grassland, with lesser representations of evergreen forest, shrublands and deciduous forest.

- Whereas impact area B (Smelter Hill) is predominantly bare ground or grassland, with only limited representation of deciduous and evergreen shrub, baseline conditions at the matching control sites consist principally of evergreen forest interspersed with grassland.

- Whereas impact area C (Mt. Haggin) is predominantly grassland and bare ground, with limited representation of deciduous and evergreen shrub, baseline conditions at the matching control sites consist principally of evergreen forest with lesser representation of all other cover types.

These results suggest that much of the area delineated as potentially injured once supported forests. Figure 3-4 confirms this by showing the sampling points at which evidence of previous afforestation (dead trees or stumps) was found. Within the injured area, deforestation and replacement by bare ground has occurred. In contrast to the impact sites, bare ground was recorded rarely in the control areas (Figures 3-1 through 3-3).

The results of One-sample Randomization Tests on the observed differences between control and impact sites in evergreen forest, grassland and bare ground cover type proportional representations are presented in Table 3-1. These results show that in all three study areas there was significantly less proportional representation of evergreen forest and more of bare ground than in the respective control areas.

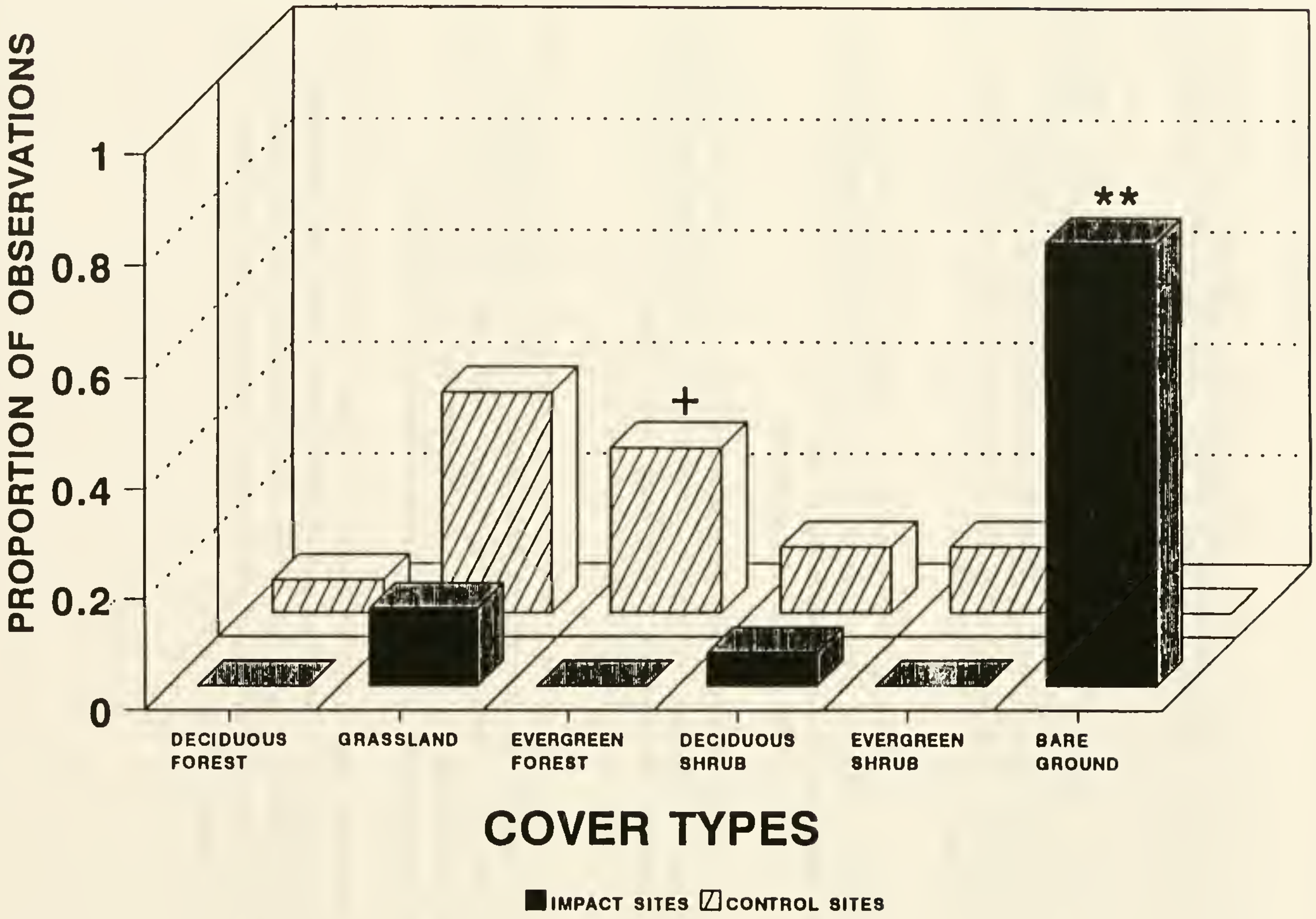

Figure 3-1. **Proportional Representation of the Cover Types of Stucky Ridge (Area A) and Corresponding Control Sites.** + and ** indicate significant differences in the proportional representation at α = 10% and 3.3%, respectively.

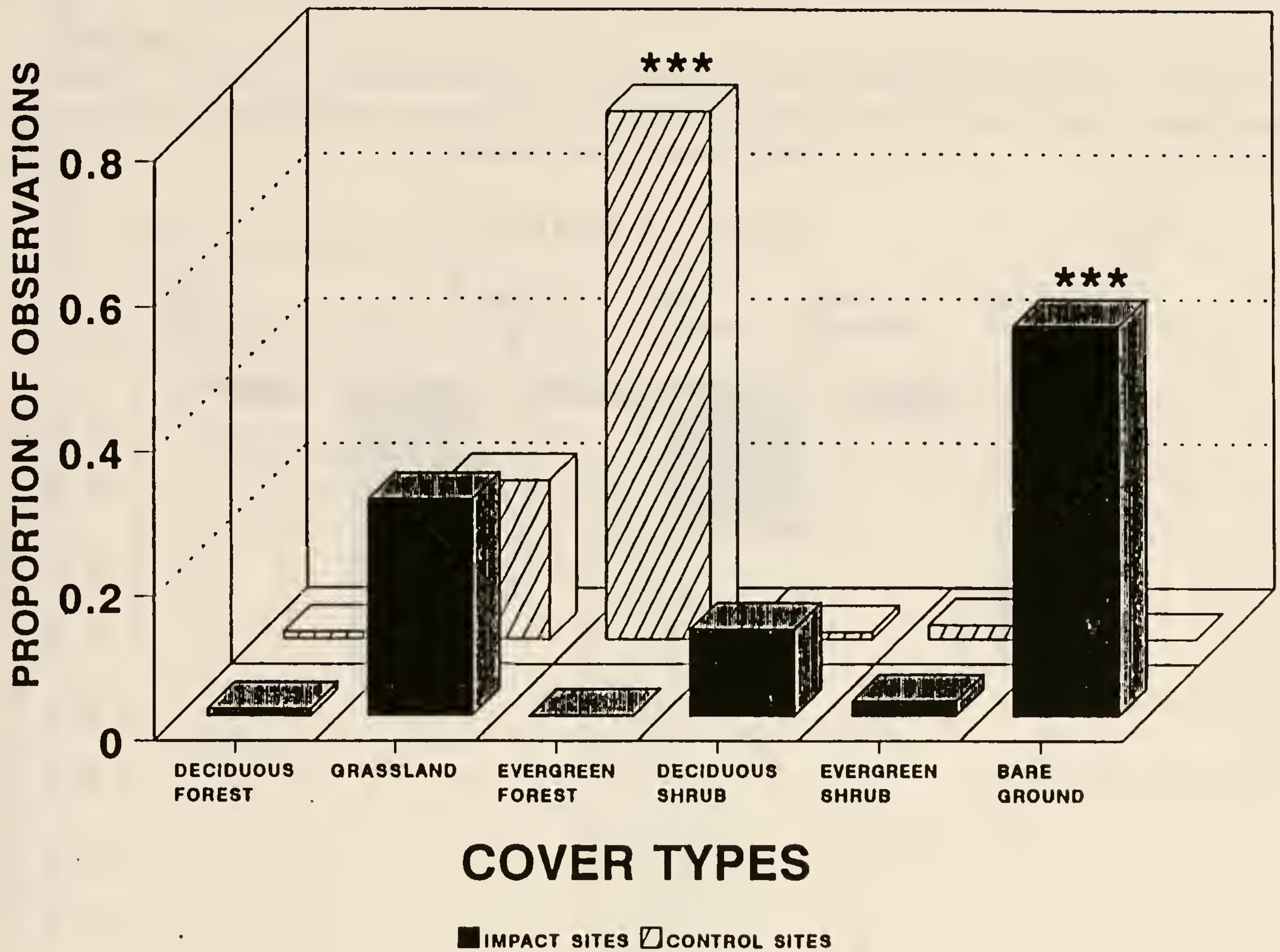

Figure 3-2. **Proportional Representation of the Cover Types of Smelter Hill (Area B) and Corresponding Control Sites.** *** Indicates a significant difference in proportional representation at α = 1%.

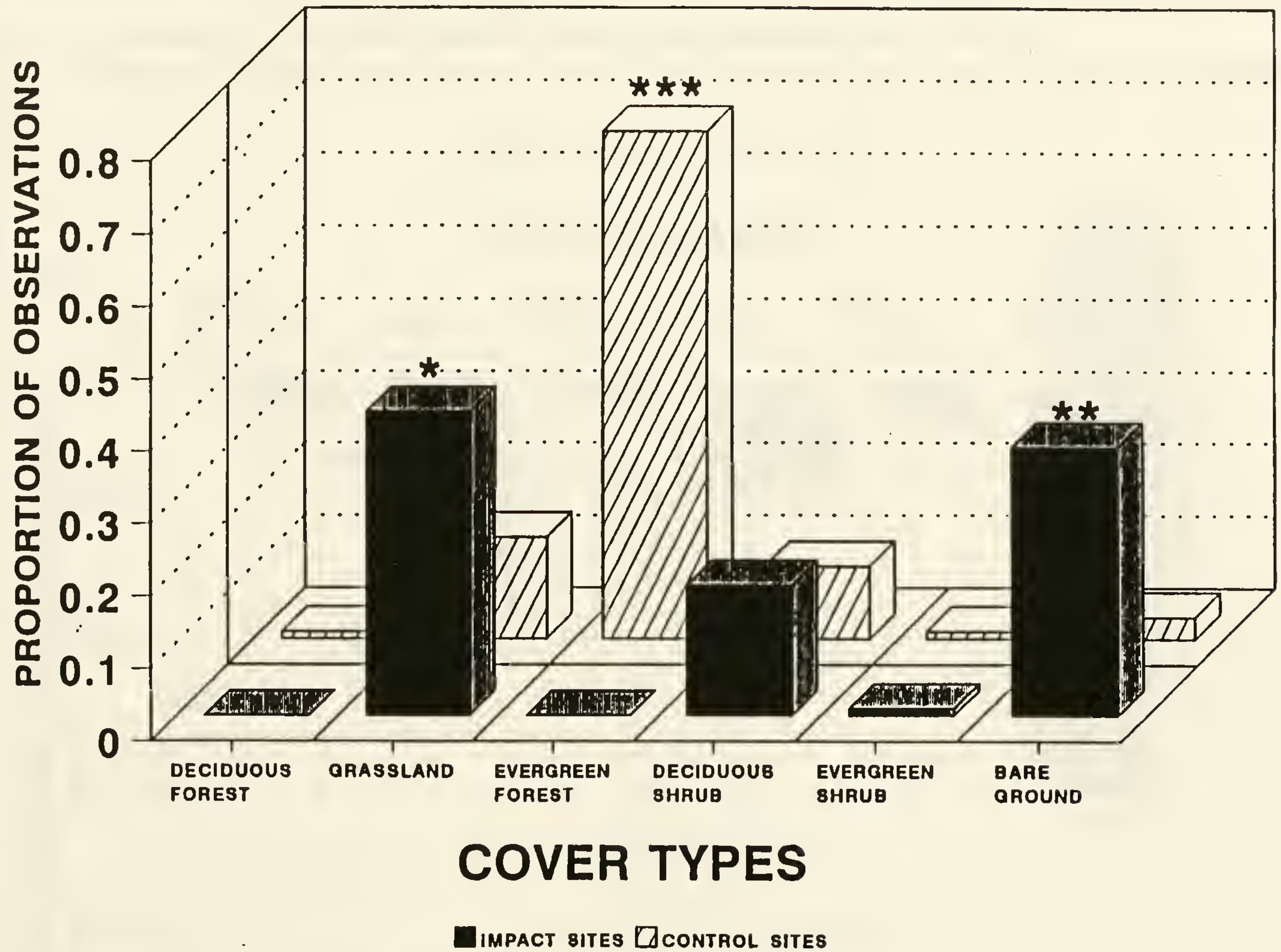

Figure 3-3. **Proportional Representation of the Cover Types of Mount Haggin (Area C) and Corresponding Control Sites.** *, **, and *** indicate significant differences in proportional representation at $\alpha = 5\%$, 3.3%, and 1%, respectively.

Figure 3-4. Sampling Sites Showing Evidence or No Evidence of Previous Afforestation. + = evidence of previous afforestation, ○ = no evidence of previous afforestation.

Table 3-1
Paired Comparison of Proportional Cover Type Representation in Impact and Control Sites Using One-Sample Randomization Tests

Area	Cover Type	p-Value
1) All impact areas vs. pooled controls	Evergreen forest	0.0002***
	Grassland	0.23
	Bare ground	0.0002***
2) Stucky Ridge vs. matched controls	Evergreen forest	0.06 ⁺
	Grassland	0.93
	Bare ground	0.031**
3) Smelter Hill vs. matched controls	Evergreen forest	0.002***
	Grassland	0.31
	Bare ground	0.002***
4) Mt. Haggin vs. matched controls	Evergreen forest	0.008***
	Grassland	0.04*
	Bare ground	0.031**

⁺ = Significant at $p < 0.1$.
* = Significant at $p < 0.05$.
** = Significant at $p < 0.033$.
*** = Significant at $p < 0.01$.

The vegetational composition of cover types identified as grasslands in impact versus control areas was investigated using line intercept measurements. Two analyses were performed. Firstly, the cover of bare ground in impact area grasslands was compared to the cover of bare ground in corresponding paired control area grasslands. Secondly, the average percent covers of grassland plants defined as "native" or as "invasive weeds" were compared between impact and control data.

Eight pairs of upland control and impact sites included grassland cover type. The mean percent cover of bare ground for these sites was 11.0% and 61.7% respectively. The probability of these differences in cover being due to chance was obtained using a One-sample Randomization Test and found to be significant for $p < 0.01$ (one-tailed test). Thus,

vegetation classified as grassland in the impact areas is significantly sparser (i.e., has more bare ground) than vegetation classified as grasslands in the control areas.

In the eight pairs of upland control and impact sites that included grassland the mean percent cover of native species at control and impact sites was 34.5% and 10.9%, respectively. The mean percent cover of invasive species at control and impact sites was 9.8% and 7.4%, respectively. The observed differences between control and impact sites were tested using One-sample Randomization Tests. These showed that the probability of the greater cover of native species in the control areas being due to chance was significant at $p < 0.01$ (one-tailed test) and the difference in cover of invasive species at control and impact sites being due to chance was not significant at $p < 0.85$. Thus, there is significantly less cover of native grassland species in the impact area grasslands.

Thus, injury to upland grassland has resulted in a diminution in the cover of native species and an increase in the area occupied by bare, devegetated ground.

Presence of Habitat Layers

Figures 3-5 through 3-7 show the proportional representations of habitat layers at impact and control sites. The three impact areas lack two of the five vegetation layers (tree canopy and bole) characteristic of the control areas. Furthermore, the remaining three layers (shrub midstory, understory, and terrestrial subsurface) have a significantly greater proportional representation at control sites than in the impact areas (Table 3-2).

Numbers of Habitat Layers

Figures 3-8 through 3-10 show the proportional representations of the numbers of habitat layers at impact and control sites. Whereas the number of habitat layers in control areas ranges between two and five, the number at impact sites ranges from zero to three. The greatest proportion of observations in the control areas was of five habitat layers; proportions of observations in impact areas were more evenly distributed between zero to three layers.

The mean number of layers per site within impact areas was compared to the mean number per site in control areas (Table 3-3). Significantly greater numbers of layers were recorded at all control sites compared to their respective impact sites.

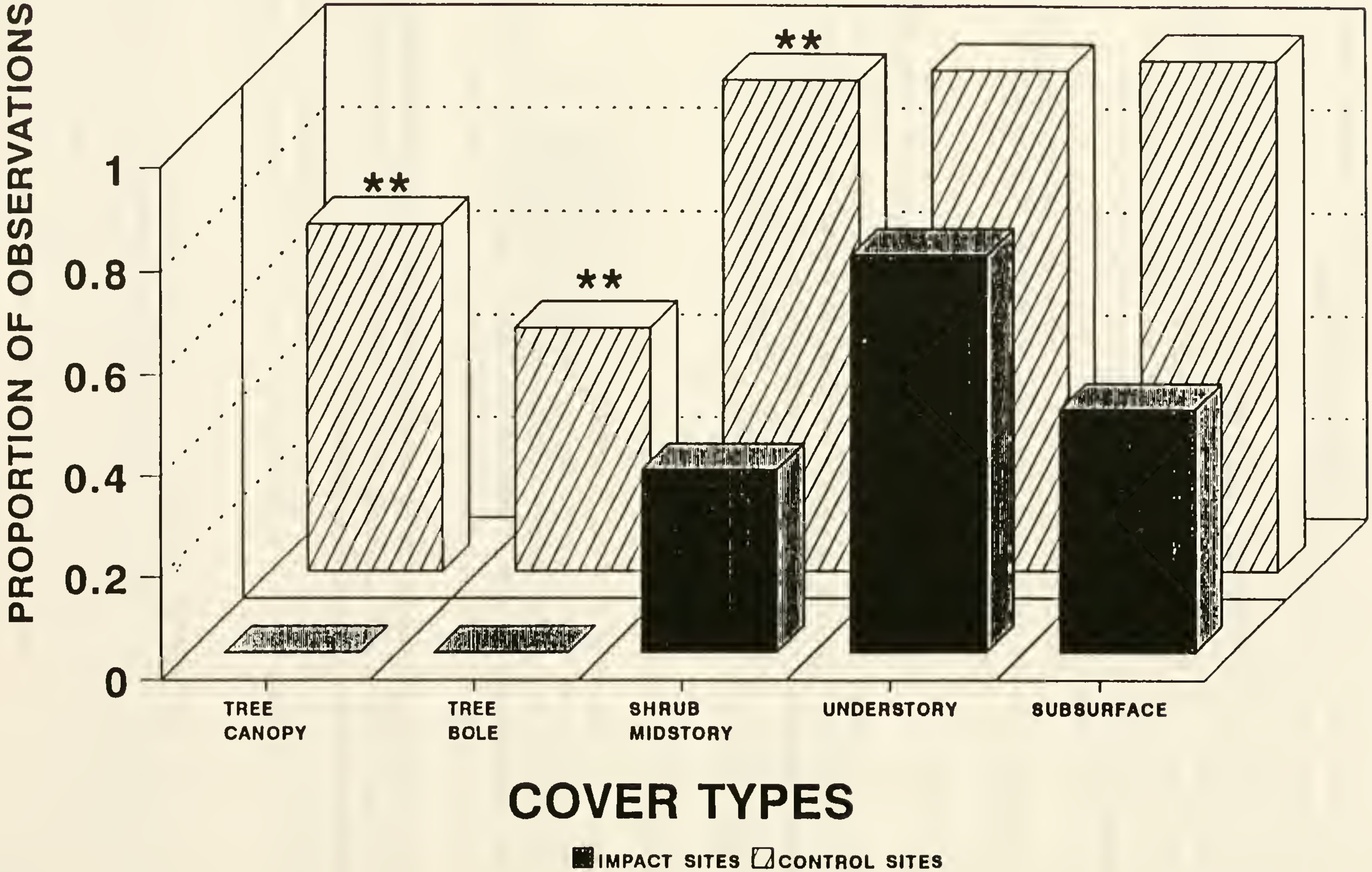

Figure 3-5. Proportional Representation of the Habitat Layers of Stucky Ridge (Area A) and Corresponding Control Sites. ** Indicates significant difference in proportional representation at $\alpha = 3.3\%$.

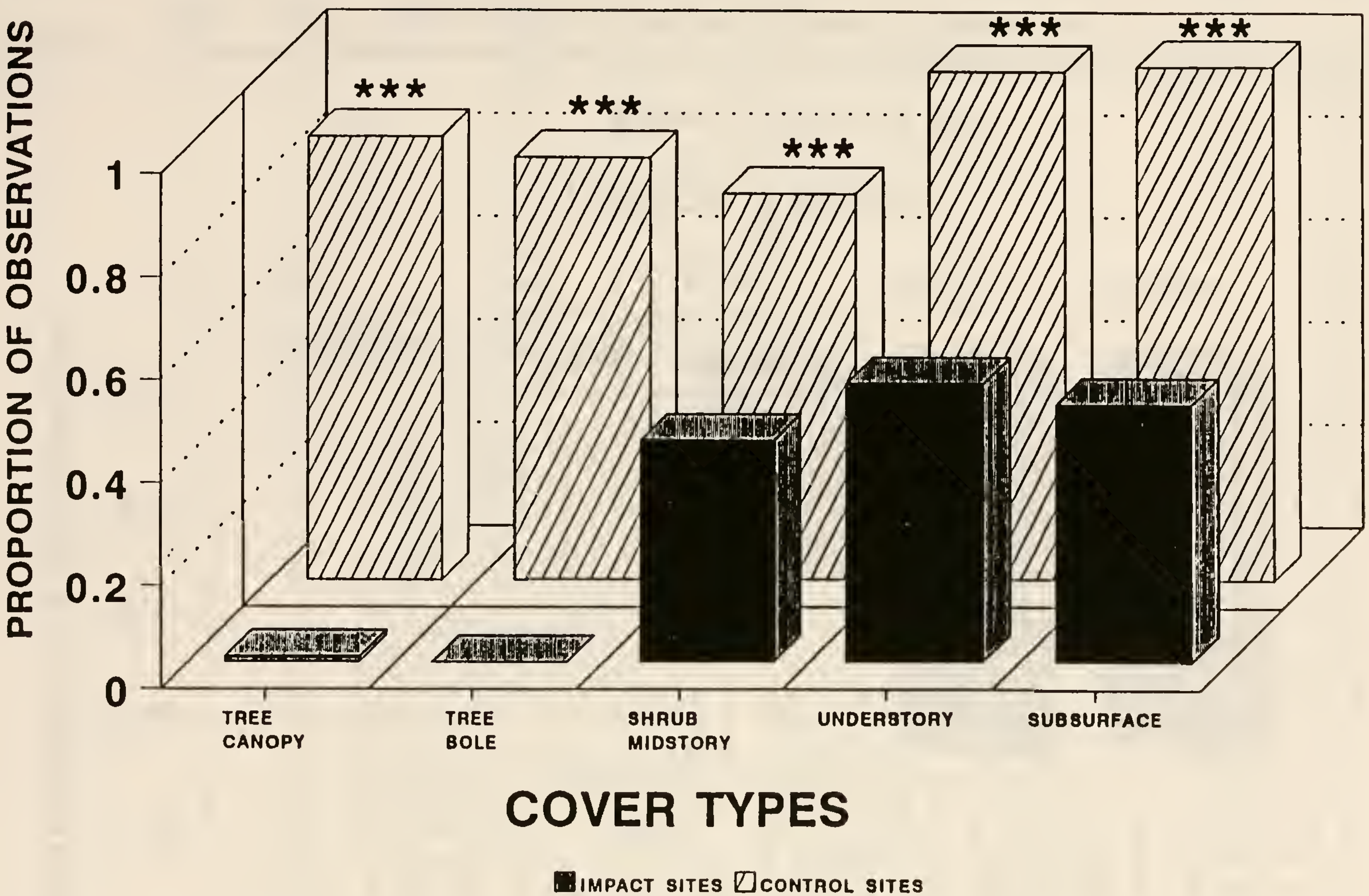

Figure 3-6. **Proportional Representation of the Habitat Layers of Smelter Hill (Area B) and Corresponding Control Sites.** *** Indicates significant difference in proportional representation at $\alpha = 1\%$.

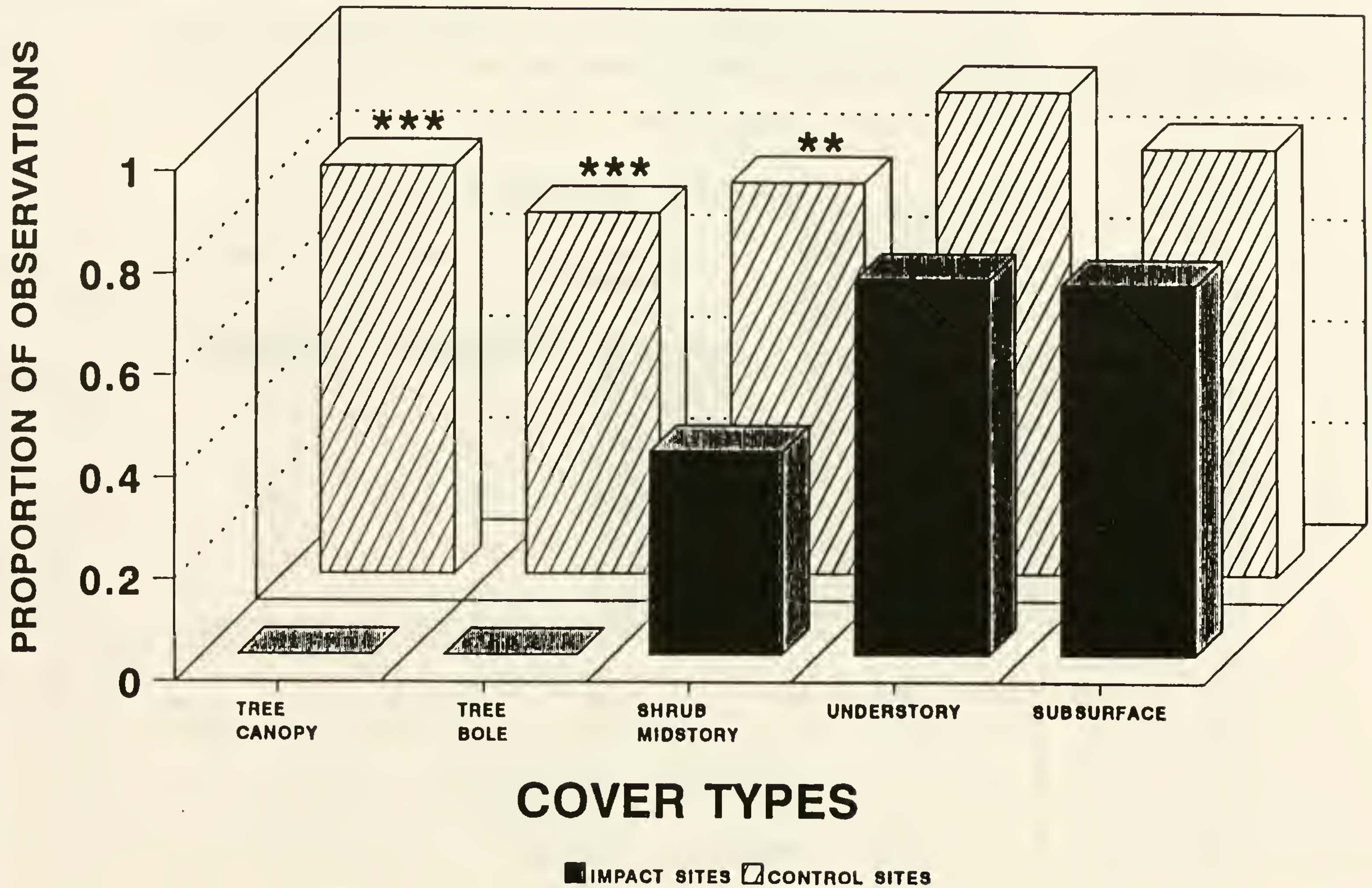

Figure 3-7. Proportional Representation of the Habitat Layers of Mount Haggin (Area C) and Corresponding Control Sites. ** and *** indicate significant differences in proportional representation at α = 3.3% and 1%, respectively.

Table 3-2
Paired Comparisons of Proportional Representations of Habitat Layers in Impact and Control Areas Using One-Sample Randomization Tests

Area	Habitat Layers	p-Value
1) All impacts vs. pooled controls	Tree canopy	0.0002***
	Tree bole	0.0002***
	Shrub midstory	0.0004***
	Understory	0.0002***
	Terrestrial subsurface	0.0002***
2) Stucky Ridge vs. matched controls	Tree canopy	0.03125**
	Tree bole	0.03125**
	Shrub midstory	0.03125**
3) Smelter Hill vs. matched controls	Tree canopy	0.00195***
	Tree bole	0.00195***
	Shrub midstory	0.00977***
	Understory	0.00195***
	Terrestrial subsurface	0.00195***
4) Mt. Haggin vs. matched controls	Tree canopy	0.00781***
	Tree bole	0.00781***
	Shrub midstory	0.03125**

** = Significant at $p < 0.033$.
*** = Significant at $p < 0.01$.

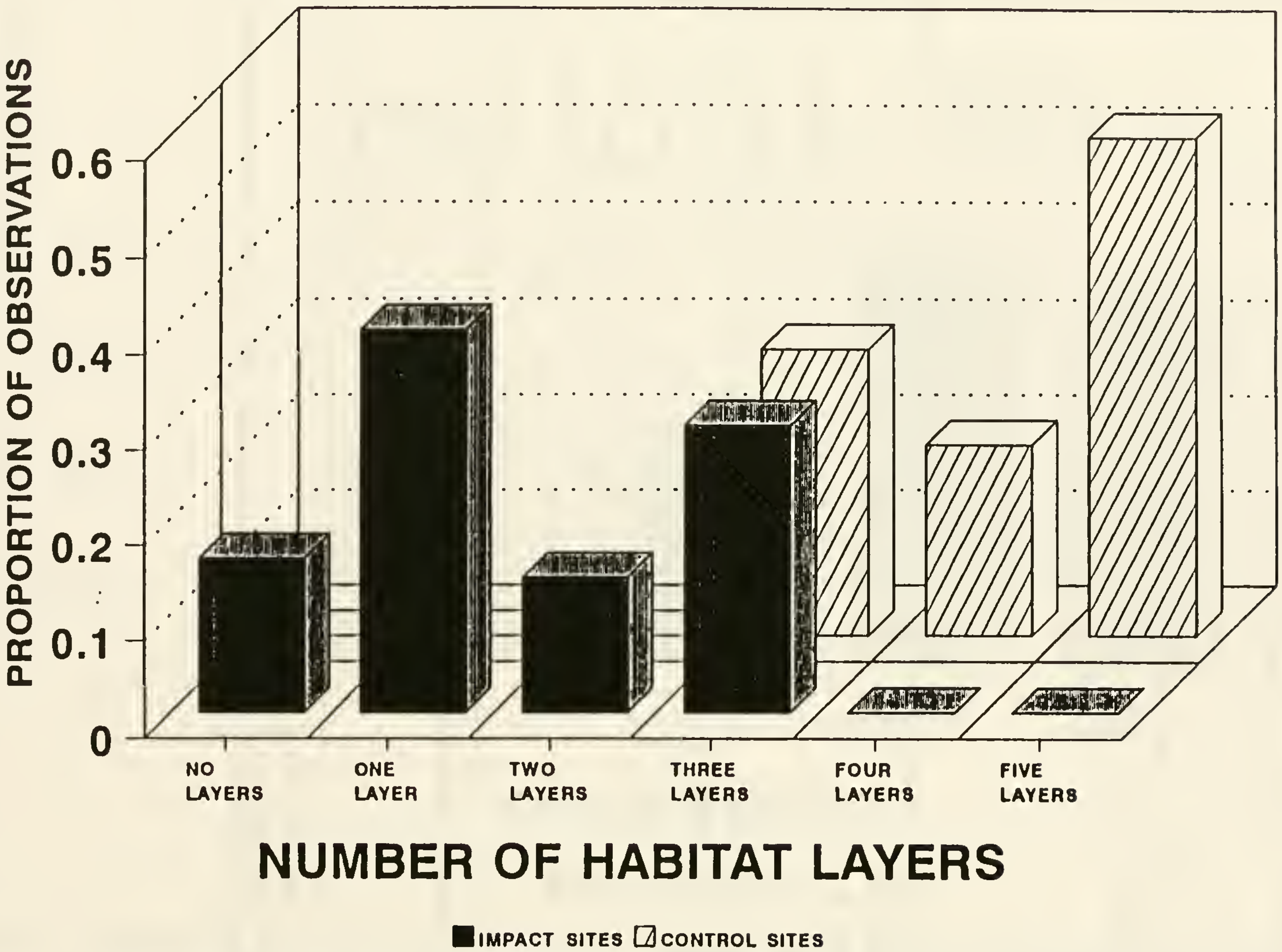

Figure 3-8. Proportional Representation of the Number of Habitat Layers of Stucky Ridge (Area A) and Corresponding Control Sites.

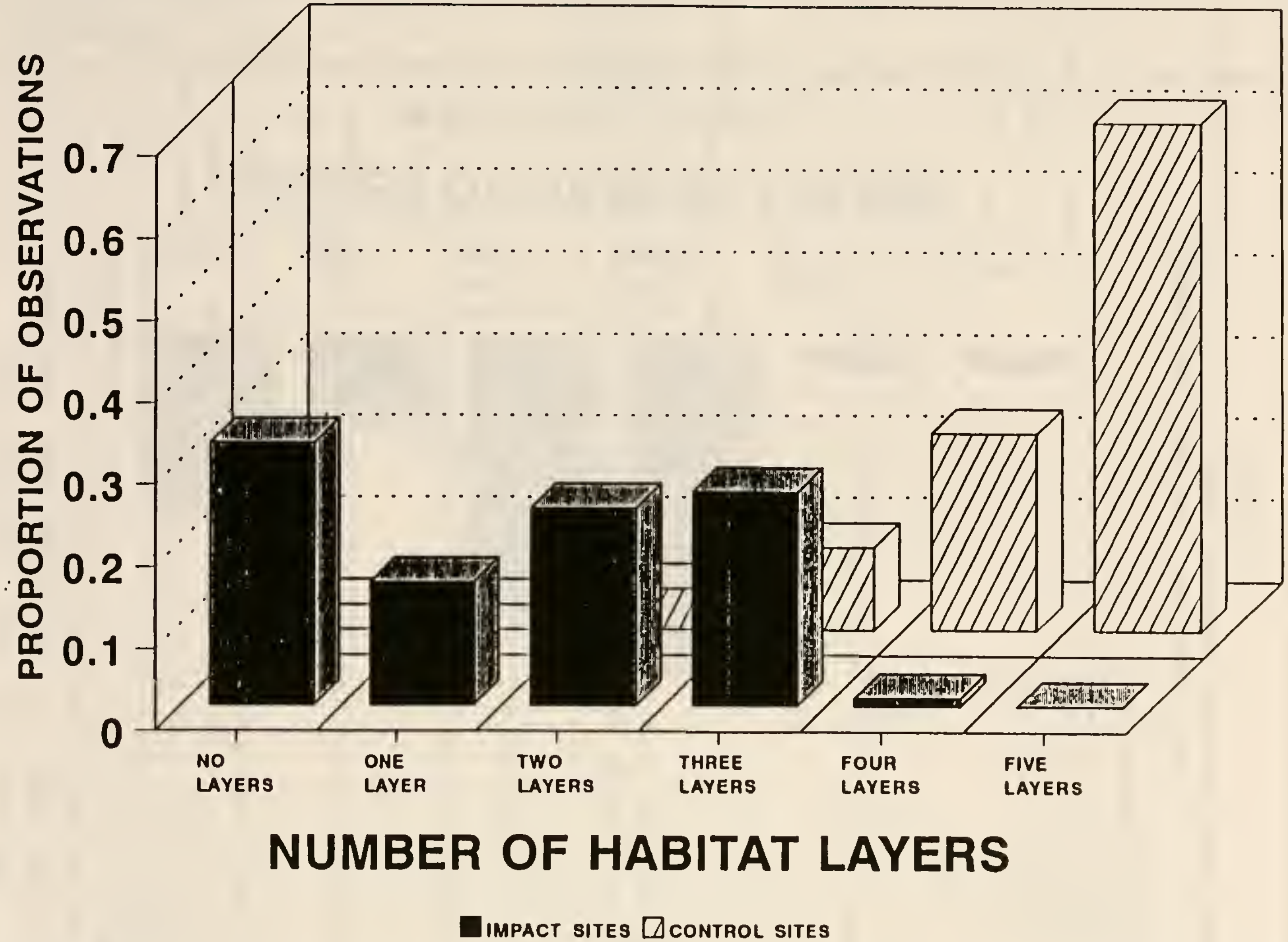

Figure 3-9. Proportional Representation of the Number of Habitat Layers of Smelter Hill (Area B) and Corresponding Control Sites.

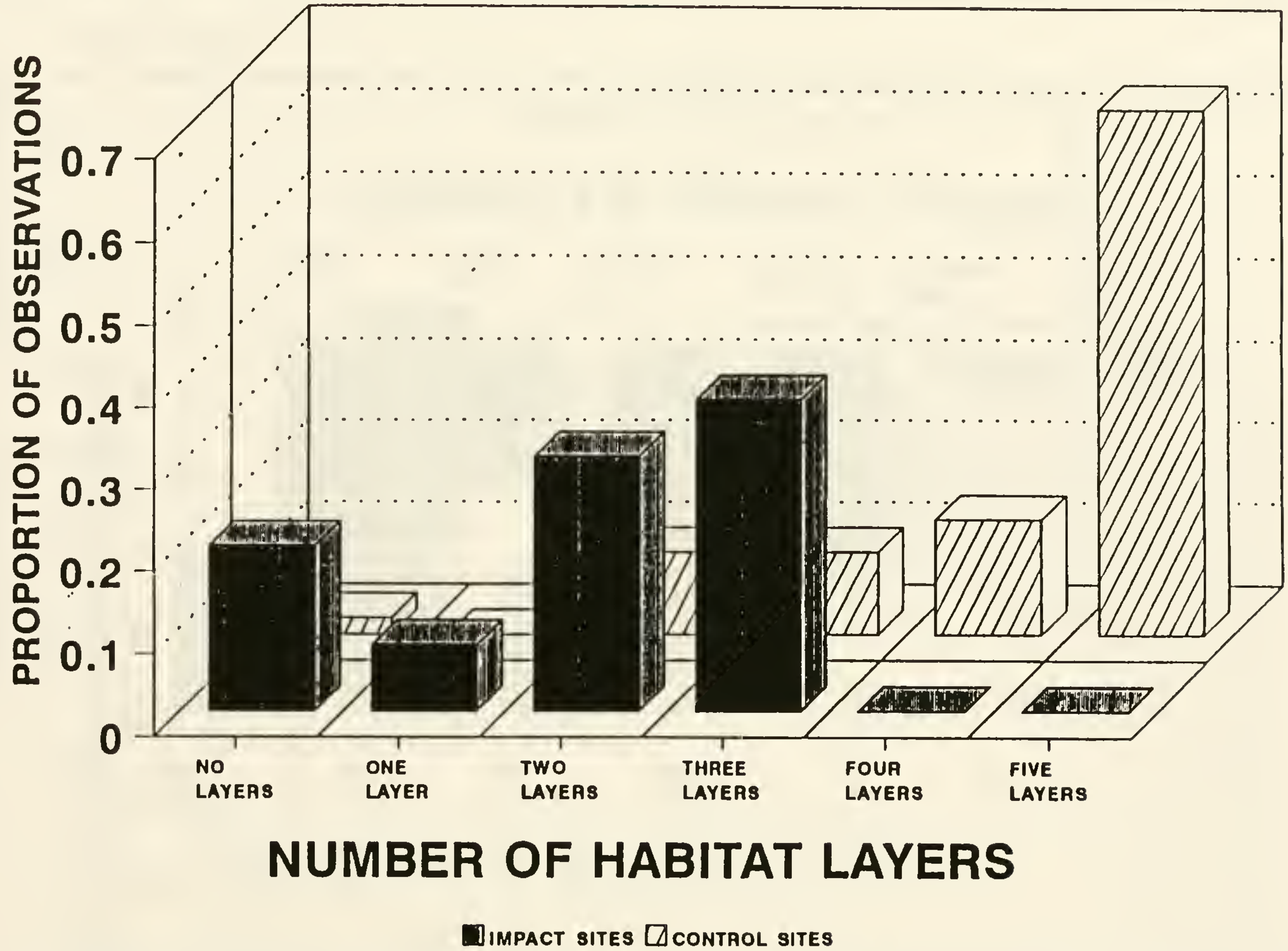

Figure 3-10. Proportional Representation of the Number of Habitat Layers of Mount Haggin (Area C) and Corresponding Control Sites.

Table 3-3
One-Tailed Paired Comparison Randomization Tests of the Differences in Mean Number of Habitat Layers in Impact versus Control Areas

Area	p-Value
1) All impacts vs. pooled controls	0.0002***
2) Stucky Ridge vs. controls	0.03125**
3) Smelter Hill vs. controls	0.00195***
4) Mt. Haggin vs. controls	0.00781***

** = Significant at $p < 0.033$.
*** = Significant at $p < 0.01$.

3.2 UPLAND WILDLIFE

3.2.1 Marten Injury Determination

The HSI values obtained using the marten HEP model are displayed in Table 3-4. One-tailed One-sample Randomization Tests on these values revealed that HSI values for impact sites are significantly smaller than those in corresponding control sites when:

- All impact sites are compared with corresponding control sites ($p < 0.0002$).
- Smelter Hill impact sites are compared with corresponding control sites ($p < 0.004$).
- Mount Haggin impact sites are compared with their corresponding control sites ($p < 0.008$).

These results demonstrate that Marten habitat at the Smelter Hill and Mount Haggin control sites is of significantly higher quality than is found at their respective impact sites. The probability value obtained for Stucky Ridge and its control sites was $p < 0.06$. Although this value strongly suggests a significant difference, it is not as great as those found between Smelter Hill and Mount Haggin and their control areas. Since Stucky Ridge is comparatively low-lying, its extent of forestation prior to injury would have been less than the other two injured upland areas (this is supported by the cover type results that indicate that only 30% of

Table 3-4
Marten HEP Data

Site	Treatment	V1	SIV1	V2	SIV2	V3	SIV3	V4	SIV4	HSI
A8	IMPACT	0	0	0	0.1	0	0	0	0.5	0
A10	IMPACT	0	0	0	0.1	0	0	0	0.5	0
A2	IMPACT	0	0	0	0.1	0	0	0	0.5	0
A3	IMPACT	0	0	0	0.1	0	0	0	0.5	0
A6	IMPACT	0	0	0	0.1	0	0	0	0.5	0
AA8	CONTROL	0	0	0	0.1	0	0	0	0.5	0
AA10	CONTROL	91	1	100	1	1	1	3.3	0.58	0.76
AA2	CONTROL	50	1	100	1	1	1	12.6	0.75	0.87
AA3	CONTROL	38	0.54	100	1	1	1	0	0.5	0.52
AA6	CONTROL	29	0.17	100	1	1	1	0	0.5	0.29
B11	IMPACT	0	0	0	0.1	0	0	0	0.5	0
B13	IMPACT	0	0	0	0.1	0	0	0	0.5	0
B15	IMPACT	0	0	0	0.1	0	0	0	0.5	0
B16	IMPACT	0	0	0	0.1	0	0	0	0.5	0
B19	IMPACT	0	0	0	0.1	0	0	0	0.5	0
B2	IMPACT	0	0	0	0.1	0	0	0	0.5	0
B5	IMPACT	0	0	0	0.1	0	0	0	0.5	0
B7	IMPACT	0	0	0	0.1	0	0	0	0.5	0
B9	IMPACT	0	0	0	0.1	0	0	0	0.5	0
BB11	CONTROL	7.2	0	100	1	1	1	3.4	0.52	0
BB13	CONTROL	41	0.6	100	1	1	1	4.3	0.55	0.57
BB15	CONTROL	75	1	100	1	1	1	2.6	0.5	0.71
BB16	CONTROL	71	1	100	1	1	1	2.2	0.5	0.71

Table 3-4 (cont.)
Marten HEP Data

Site	Treatment	V1	SIV1	V2	SIV2	V3	SIV3	V4	SIV4	HSI
BB19	CONTROL	53	1	100	1	1	1	1	0.5	0.71
BB2	CONTROL	48	0.98	100	1	1	1	19.8	1	0.99
BB5	CONTROL	62	1	100	1	1	1	8	0.7	0.83
BB7	CONTROL	71	1	100	1	1	1	2.4	0.5	0.71
BB9	CONTROL	42	0.7	100	1	1	1	4.8	0.6	0.65
C1	IMPACT	0	0	0	0.1	0	0	0	0.5	0
C12	IMPACT	0	0	0	0.1	0	0	0	0.5	0
C14	IMPACT	0	0	0	0.1	0	0	0	0.5	0
C5	IMPACT	0	0	0	0.1	0	0	0	0.5	0
C3	IMPACT	0	0	0	0.1	0	0	0	0.5	0
C7	IMPACT	0	0	0	0.1	0	0	0	0.5	0
C9	IMPACT	0	0	0	0.1	0	0	0	0.5	0
CC1	CONTROL	100	1	100	1	1	1	13.5	0.83	0.91
CC12	CONTROL	76	1	100	1	1	1	11	0.76	0.87
CC14	CONTROL	74	1	100	1	1	1	6.8	0.68	0.82
CC5	CONTROL	55	1	100	1	1	1	21.6	1	1
CC3	CONTROL	42	0.7	100	1	1	1	5.5	0.6	0.65
CC7	CONTROL	50	1	100	1	1	1	5.7	0.6	0.77
CC9	CONTROL	83	1	100	1	1	1	12.2	0.78	0.88

A = Stucky Ridge; B = Smelter Hill; C = Mt. Haggin; V1 = % canopy closure; V2 = % conifers in canopy; V3 = successional stage of stand; V4 = % downfall; SIV1 to SIV4 are the suitability indexes for each of the four variables; and HSI is the suitability index for each sample site.

Stucky Ridge would be forested, compared with more than 70% for Smelter Hill and Mount Haggin). Thus, the marten HEP model results are consistent with what would be expected based on likely pre-impact patterns of forest cover.

3.2.2 Marten Injury Quantification

Approximately 70% of Smelter Hill and Mount Haggin, and 30% of Stucky Ridge impact areas were likely to have been forested with conifers prior to the release of hazardous substances (Figures 3-1 through 3-3). This is a total area of about 11 square miles over which marten habitat has been entirely lost.

3.2.3 Elk Injury Determination

The HEf, HEc and HE values obtained using the elk model are presented in Tables 3-5 through 3-7. One-sample Randomization Tests (one-tailed) carried out on these results (Table 3-8) show that cover quality, forage quality and overall habitat quality (HE) are significantly higher on control sites when:

- All impact sites are compared with pooled control sites.
- Stucky Ridge impact sites are compared with corresponding control sites.
- Smelter Hill impact sites are compared with corresponding control sites.
- Mt. Haggin impact sites are compared with corresponding control sites.

An analysis of the densities of elk pellet groups counted along control and impact line transects provides evidence that the impact sites were used less by elk than the control sites. Table 3-9 displays the mean densities of pellet groups in the three main impact areas and at their control sites. One-sample Randomization Tests (one-tailed) revealed that the density of pellet groups was significantly higher on control sites when:

- All impact sites were compared with their corresponding control sites ($p < 0.0002$).

- Smelter Hill impact sites were compared with corresponding control sites ($p < 0.004$).

- Mt. Haggin impact sites were compared with corresponding control sites ($p < 0.03$).

Table 3–5
Distribution of Elk Cover and HEc Values

SITE	CONTROL/IMPACT	P>50%CC	P31–50%CC	P10–30%CC	P<10%CC	HEc
STUCKY RIDGE	IMPACT	0	0	0	1	0.1
SMELTER HILL	IMPACT	0	0	0.01	0.99	0.103
MT HAGGIN	IMPACT	0	0	0.02	0.98	0.106
AA2	CONTROL	0.30	0.01	0.22	0.47	0.443
AA10	CONTROL	0.11	0	0.29	0.6	0.286
AA6	CONTROL	0.1	0	0.27	0.63	0.271
AA3	CONTROL	0.11	0.4	0	0.49	0.479
AA8	CONTROL	0.07	0	0.33	0.6	0.262
BB2	CONTROL	0.55	0.02	0.20	0.23	0.669
BB3	CONTROL	0.5	0	0.05	0.45	0.565
BB5	CONTROL	0.21	0.2	0.03	0.56	0.438
BB7	CONTROL	0.83	0.09	0.04	0.04	0.922
BB9	CONTROL	0.73	0.05	0.07	0.14	0.812
BB11	CONTROL	0.33	0.02	0	0.65	0.411
BB15	CONTROL	0.5	0	0.05	0.45	0.565
BB13	CONTROL	0.21	0.16	0.23	0.40	0.470
BB16	CONTROL	0.54	0.03	0	0.43	0.607
CC1	CONTROL	0.23	0.11	0.07	0.6	0.406
CC3	CONTROL	0.30	0.1	0	0.6	0.440
CC5	CONTROL	0.21	0.07	0.09	0.63	0.365
CC7	CONTROL	0.23	0.17	0.05	0.54	0.440
CC9	CONTROL	0.28	0.02	0.21	0.49	0.429
CC12	CONTROL	0.65	0.17	0	0.18	0.804
CC14	CONTROL	0.8	0.2	0	0	0.960

A=Stucky Ridge; B=Smelter Hill; C=Mt. Haggin.
P values are the proportions of areas/sites under various canopy closure classes. HEc is the cover suitability index for each area/site.

Table 3-6
Percent Cover of Elk Forage Palatability Classes and HEf Values at Impact and Control Sites for All % Canopy Closure Classes

Site	% Canopy Closure Class	% V1 Sp.[1]	% V2 Sp.[2]	% V3 Sp.[3]	% Nonforage[4]	HEf
Stucky Ridge						
Controls	< 10	28.0	8.0	11.1	56.7	0.35
	10-30	23.8	16.3	10.25	7.2	0.34
	31-50	3.0	13.0	2.29	5.0	0.10
	> 50	2.3	8.0	1.9	84.0	0.07
Impacts	< 10	2.4	1.1	11.8	87.3	0.04
Smelter Hill						
Controls	< 10	14.4	27.5	8.0	42.7	0.30
	10-30	18.1	23.4	7.6	47.0	0.32
	31-50	4.3	14.8	9.9	72.9	0.14
	> 50	0.07	21.1	4.1	78.5	0.12
Impacts	< 10	11.5	2.5	15.8	80.2	0.13
Mt. Haggin						
Controls	< 10	27.9	23.0	9.2	40.7	0.42
	10-30	12.7	37.8	30.5	38.1	0.39
	31-50	2.3	26.2	16.0	66.7	0.19
	> 50	1.0	30.2	9.4	65.5	0.18
Impacts	< 10	16.0	10.7	4.7	76.0	0.17

1 = Most valuable forage species percent cover.
2 = Less valuable forage species percent cover.
3 = Least valuable forage species percent cover.
4 = Nonforage (bare ground, rock, logs litter) percent cover.

HEf is the forage suitability index for each canopy closure class on each area.

Table 3–7
Elk HEc, HEf, and HE Values at Control and Impact Sites

SITE	TREATMENT	HEc	HEf	HE
A2	IMPACT	0.1	0.036	0.06
A10	IMPACT	0.1	0.036	0.06
A6	IMPACT	0.1	0.036	0.06
A3	IMPACT	0.1	0.036	0.06
A8	IMPACT	0.1	0.036	0.06
AA2	CONTROL	0.44	0.27	0.34
AA10	CONTROL	0.29	0.33	0.31
AA6	CONTROL	0.27	0.33	0.3
AA3	CONTROL	0.48	0.19	0.3
AA8	CONTROL	0.26	0.34	0.3
B2	IMPACT	0.1	0.13	0.11
B3	IMPACT	0.1	0.13	0.11
B5	IMPACT	0.1	0.13	0.11
B7	IMPACT	0.1	0.13	0.11
B9	IMPACT	0.1	0.13	0.11
B11	IMPACT	0.1	0.13	0.11
B15	IMPACT	0.1	0.13	0.11
B13	IMPACT	0.1	0.13	0.11
B16	IMPACT	0.1	0.13	0.11
BB2	CONTROL	0.67	0.16	0.33
BB3	CONTROL	0.56	0.16	0.3
BB5	CONTROL	0.44	0.18	0.28
BB7	CONTROL	0.92	0.09	0.29
BB9	CONTROL	0.81	0.11	0.3
BB11	CONTROL	0.41	0.19	0.28
BB15	CONTROL	0.56	0.16	0.3
BB13	CONTROL	0.47	0.2	0.31
BB16	CONTROL	0.61	0.15	0.3
C1	IMPACT	0.1	0.17	0.13
C3	IMPACT	0.1	0.17	0.13
C5	IMPACT	0.1	0.17	0.13
C7	IMPACT	0.1	0.17	0.13
C9	IMPACT	0.1	0.17	0.13
C12	IMPACT	0.1	0.17	0.13
C14	IMPACT	0.1	0.17	0.13
CC1	CONTROL	0.41	0.27	0.33
CC3	CONTROL	0.44	0.25	0.33
CC5	CONTROL	0.36	0.28	0.32
CC7	CONTROL	0.44	0.25	0.33
CC9	CONTROL	0.43	0.27	0.34
CC12	CONTROL	0.8	0.16	0.36
CC14	CONTROL	0.96	0.13	0.35

Table 3-8
Results of One-Sample Paired Comparisons Tests on Elk HEP Data

Sites	HEc	HEf	HE
All sites vs. pooled controls	0.0002***	0.0002***	0.0002***
Stucky Ridge vs. matched controls	0.03**	0.03**	0.03**
Smelter Hill vs. matched controls	0.002***	0.04*	0.002***
Mt. Haggin vs. matched controls	0.0008***	0.03**	0.008***

* = Significant at $p < 0.05$.
** = Significant at $p < 0.03$.
*** = Significant at $p < 0.01$.

Table 3-9
Mean Densities of Elk Pellet Groups (pellet groups\20 square meters) Along Line Transects

Sites	Control Sites	Impact Sites
All sites	1.3***	0.13
Stucky Ridge	0.32	0
Smelter Hill	2.41***	0.04
Mt. Haggin	2.3**	0.3

** = Significant at $p < 0.033$.
*** = Significant at $p < 0.01$.

3.2.4 Elk Injury Quantification

Deforestation and grassland plant community modification have resulted in the virtual elimination of cover and a reduction in forage for elk over 17.8 square miles of upland habitat. Because of the elimination of cover, this area cannot provide all of the habitat requisites necessary to support a viable wintering elk population. Thus, 17.8 square miles of elk wintering habitat has been lost. Aerial surveys flown in April 1992 over the areas delineated as impacted failed to reveal any elk (D. Hook, Montana Department of Fish, Wildlife, and Parks, pers. comm.).

3.2.5 Faunal Diversity Injury Determination

The numerators, denominators and HSI values obtained using the Layers of Habitat model are shown in Table 3-10. In general, HSI values were low, reflecting the lack of habitat complexity found at the impact sites relative to that at the control sites. Habitat vertical complexity at the impact and control sites was compared statistically by performing One-sample Randomization Tests (one-tailed) on the numerators and denominators in Table 3-10. These tests showed that habitat complexity at the impact sites was significantly lower than at the control sites when:

- All impact sites were compared with their corresponding control sites ($p < 0.0002$).
- Stucky Ridge impact sites were compared with their corresponding control sites ($p < 0.03$).
- Smelter Hill impact sites were compared with their corresponding control sites ($p < 0.002$).
- Mount Haggin impact sites were compared with their corresponding control sites ($p < 0.008$).

These results demonstrate that vertical habitat complexity is significantly lower at the impact sites relative to the control sites. This reduction in complexity is primarily a function of the deforestation of the impact sites. Habitats with a complement of five layers (tree canopy, tree bole, shrub midstory, understory and terrestrial subsurface) have been reduced to habitats dominated by bare ground or sparse grassland.

3.2.6 Faunal Diversity Injury Quantification

Tables 3-11 and 3-12 list the bird and mammal species characteristic (i.e., typical inhabitants) of lodgepole pine and Douglas fir forests in southwest Montana, together with the habitat layers which they utilize when feeding, reproducing or avoiding disturbance. Many of the species listed in these tables were actually seen during fieldwork on control sites, confirming the validity of the lists. Species not seen were generally those that are extremely elusive, sparsely distributed, or nocturnal. Thus, not sighting these species may be a reflection of the animals habits rather than their absence. In contrast, during approximately two weeks of intensive fieldwork in the impacted areas in June and July 1992, only two of the avian species listed in Table 3-11 were observed: blue grouse and mountain bluebird. These are species that are dependent on forest openings for breeding habitat. During the winter, however, the blue grouse requires dense conifer forest (Johnsgard, 1992). Neither of these habitats remain in the impact area. Only one blue grouse and one pair of mountain bluebirds was observed during fieldwork in the impact areas.

Table 3-10
Results of Layers of Habitat Model and Habitat Suitability Indices (HSIs) for Upland Impact and Control Sites

Site	Habitat Suitability (Impact)	Habitat Suitability (Control)	HSI (Impact/Control)*
Stucky Ridge			
A2	720	2200	0.33
A3	100	2300	0.04
A6	630	1850	0.34
A8	450	1600	0.28
A10	330	2300	0.14
Smelter Hill			
B2	540	2250	0.24
B3	880	2350	0.37
B5	600	2100	0.28
B7	780	2400	0.32
B9	800	2400	0.03
B11	270	1700	0.16
B13	330	2050	0.16
B15	40	2350	0.02
B16	600	2350	0.25
Mt. Haggin			
C1	660	1950	0.34
C3	510	2100	0.24
C5	510	1500	0.34
C7	720	1800	0.4
C9	120	2400	0.05
C12	480	2500	0.19
C14	900	2500	0.36

* HSI values < 1 indicate less habitat suitability at impact sites than control sites.

Table 3-11
Birds Characteristic of Southwest Montana Lodgepole Pine and Douglas-Fir Forests and Their Feeding and Nesting Vegetation Layers

Species		Feeding Layers	Nesting Layers
Red-tailed hawk*	*Buteo jamaicensis*	US	TC
Sharp-shinned hawk*	*Accipiter striatus*	TC/SM	TC
Cooper's hawk	*Accipiter cooperii*	TC/SM	TC
Northern goshawk	*Accipiter gentilis*	TC/SM	TC
Blue grouse*+	*Dendragapus obscurus*	TC/SM	-
Spruce grouse	*Dendragapus canadensis*	TC/SM	-
Northern saw-whet owl	*Aegolius acadicus*	TC/SM/US	TB
Downy woodpecker*	*Picoides pubescens*	TB	TB
Hairy woodpecker*	*Picoides villosus*	TB	TB
Olive-sided flycatcher	*Contopus borealis*	-	TC
Western wood-pewee*	*Contopus sordidulus*	-	TC
Grey jay*	*Perisoreus canadensis*	US/SM/TC	TC
Steller's jay*	*Cyanocitta stelleri*	US/SM/TC	TC
Clark's nutcracker*	*Nucifraga columbiana*	TC	TC
Mountain chickadee*	*Parus gambeli*	TC/SM	TB
Red-breasted nuthatch*	*Sitta canadensis*	TB/TC	TB
House wren*	*Troglodytes aedon*	US/SM	TB
Ruby-crowned kinglet*	*Regulus calendula*	TC	TC
Mountain bluebird*+	*Sialia currucoides*	SM/US	TB
Townsend's solitaire*	*Myadestes townsedii*	TC/SM	US
Swainson's thrush*	*Catharus guttatus*	SM/US	SM
American robin*	*Turdus migratorius*	TC/SM/US	TC/SM
Cedar waxwing*	*Bombycilla cedrorum*	TC/SM	TC
Yellow-rumped warbler*	*Dendroica coronata*	TC	TC
Western tanager*	*Piranga ludoviciana*	TC/SM	TC
Chipping sparrow*	*Spizella passerina*	US	US
White-crowned sparrow*	*Zonotrichia leucophrys*	US	US
Dark-eyed junco*	*Junco hyemalis*	US	US
Pine grosbeak*	*Pinicola enucleator*	TC/SM	TC
Red crossbill*	*Loxia curvirostra*	TC	TC
Pine siskin*	*Carduelis pinus*	TC/SM	TC
Evening grosbeak*	*Coccothraustes vespertinus*	TC	TC

Sources: Bergeron et al., 1992; Johnsgard, 1992.

TC = Tree canopy
TB = Tree bole
SM = Shrub midstory
US = Understory
TS = Terrestrial subsurface.

* Indicates species observed at upland control sites during June and July 1992.
\+ Indicates species observed at upland impact sites during June and July 1992.

Table 3-12
Mammals Characteristic of Southwest Montana Lodgepole Pine and Douglas-Fir Forests and Their Cover and Foraging Vegetation Layers

Species		Feeding Layers	Cover Layers
Snowshoe hare*	*Lepus americanus*	US/SM	US
Red squirrel*	*Tamiasciurus hudsonicus*	TC/US	TC
Porcupine	*Erithezon dorsatum*	TC/SM	TC
Black bear	*Ursus americanus*	SM/US	US
Pine marten	*Martes americana*	TC/US	TC/TS
Ermine	*Mustella erminea*	US	US/TS
Mountain lion	*Felis concolor*	SM/US	TS
Bobcat	*Felis rufus*	SM/US	TS
Lynx	*Felis lynx*	SM/US	TS/SM
Elk*+	*Cervus elaphus*	SM/US	TS/SM

Reference: Chapman and Feldhamer (1982).

TC = Tree canopy
TB = Tree bole
SM = Shrub midstory
US = Understory
TS = Terrestrial subsurface.

* Indicates species observed at upland control study sites during June and July 1992.
\+ Indicates species observed at upland impact sites during June and July 1992.

Populations of organisms dependent on tree canopy and tree bole are likely to have suffered the greatest injury from the loss of upland conifer forest in the impact areas. Species that are likely to have been lost from the injured areas as a result of this habitat loss are listed in Table 3-13. Other populations of upland conifer forest organisms less dependent on tree canopy and bole have likely suffered reduced viability because of the diminished representation of shrub, herbaceous and soil layers in the impact areas.

Twenty-seven (84%) of the 32 bird species listed in Table 3-11 are dependent on the presence of tree canopy and bole for breeding or foraging niches. These species are likely to have been lost from the impacted areas as a result of the loss of these layers (Table 3-13). The remaining five species have likely suffered reduced viability.

Forty percent of the mammal species listed in Table 3-12 are strictly arboreal or dependent on dense conifer cover. These have likely been lost from the impact areas as a result of tree canopy loss (Table 3-13). The remaining six species have likely suffered reduced viability.

3.3 RIPARIAN VEGETATION

3.3.1 Cover Type

Cover type proportional representations in relation to distance from the river on control and impact river reaches are presented in Figures 3-11 and 3-12. Sample point 1 on each transect was immediately adjacent to the river while sample point 10 was 100 meters inland. Whereas the impact transects were dominated by one main cover type, slickens or tailings (approximately 80% of observations), control sites were predominantly either shrub/forest (shrub and forest combined), hay, or pasture. A marked distribution of cover types in relation to proximity to the stream is evident on the control streams. Shrub/forest is the most prevalent cover type in immediate proximity to the stream but is replaced by hay or pasture fields at increasing distance from the water's edge. Figure 3-13 presents a comparison between impact and reference transects, showing the proportional representation of the single common cover-type, shrub/forest. Riparian shrub/forest was more prevalent on control than impact reaches.

These differences were tested for statistical significance using a Blocked One-Way Analysis of Variance Randomization Test comparing the proportions of cover types on the 17 impact and 18 control transects where the data were blocked by reach. The proportional representation of slickens was significantly higher on the impact than on the control transects ($p = 0.0002$). The proportional representations of hay, pasture and riparian forest were significantly higher on the control than the impact streams ($p = 0.002$, 0.0002, and 0.009, respectively).

Table 3-13
Bird and Mammal Populations that are Likely to have been Lost or Suffered Reduced Population Viability Because of Removal of Tree Canopy, Bole, Shrub Midstory, Understory and Terrestrial Subsurface Habitat Layers in Upland Impact Areas

Reduced Viability	Lost Species
Swainsons thrush	Red-tailed hawk
American robin	Sharp-shinned hawk
Chipping sparrow	Cooper's hawk
White-crowned sparrow	Northern goshawk
Dark-eyed junco	Blue grouse
Black bear	Spruce grouse
Ermine	Northern saw-whet owl
Snowshoe hare	Downy woodpecker
Mountain lion	Hairy woodpecker
Bobcat	Olive-sided flycatcher
Elk	Western wood-pewee
	Grey jay
	Steller's jay
	Clark's nutcracker
	Mountain chickadee
	Red-breasted nuthatch
	House wren
	Ruby-crowned kinglet
	Mountain bluebird
	Townsend's solitaire
	Cedar waxwing
	Yellow-rumped warbler
	Western tanager
	Pine grosbeak
	Red crossbill
	Pine siskin
	Evening grosbeak
	Red squirrel
	Porcupine
	Pine marten
	Lynx

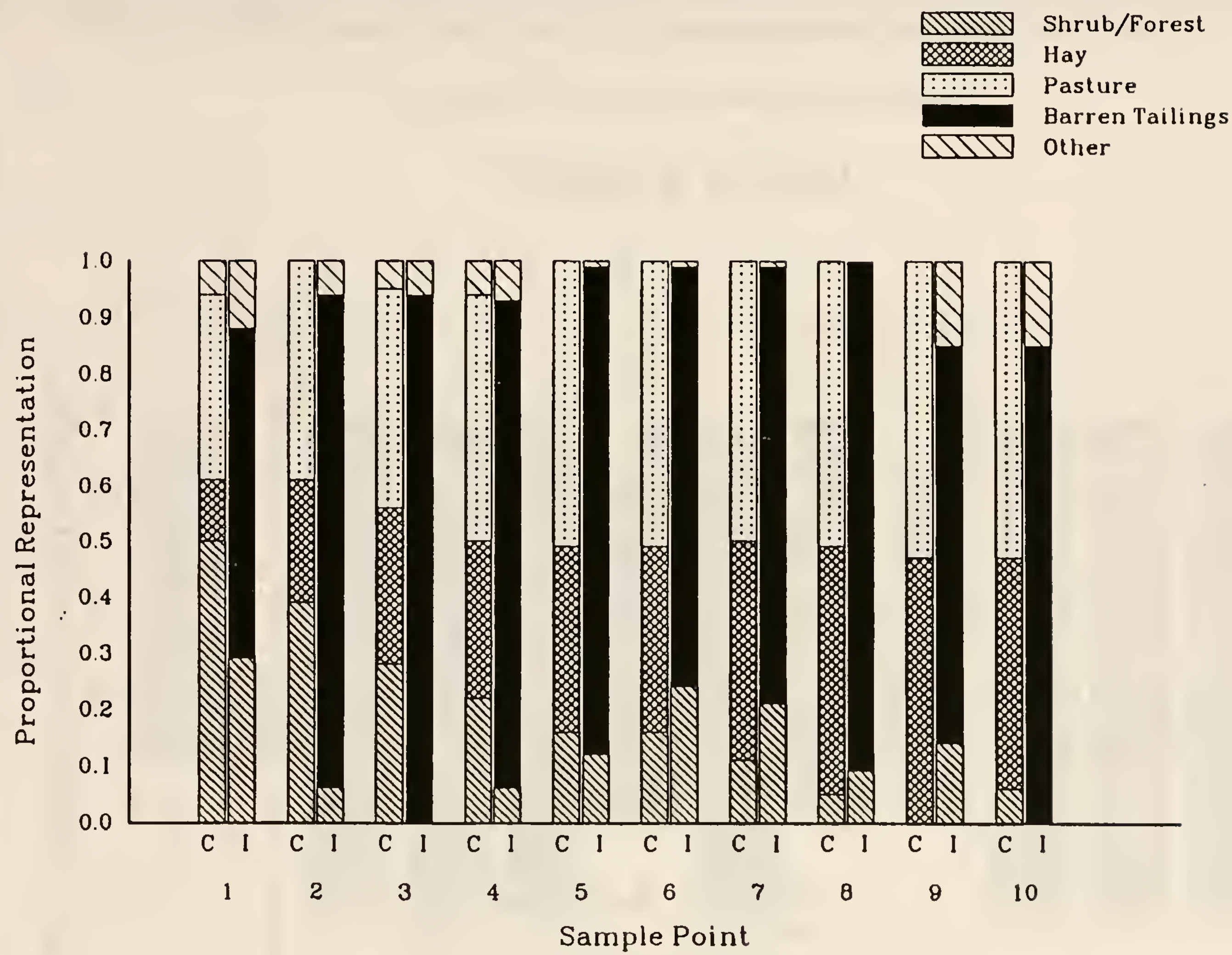

Figure 3-11. Proportional Representation of the Dominant Cover Types Encountered on Riparian Control (C) and Impact (I) Reaches. Sample points represent distance from the river at 10 meter intervals.

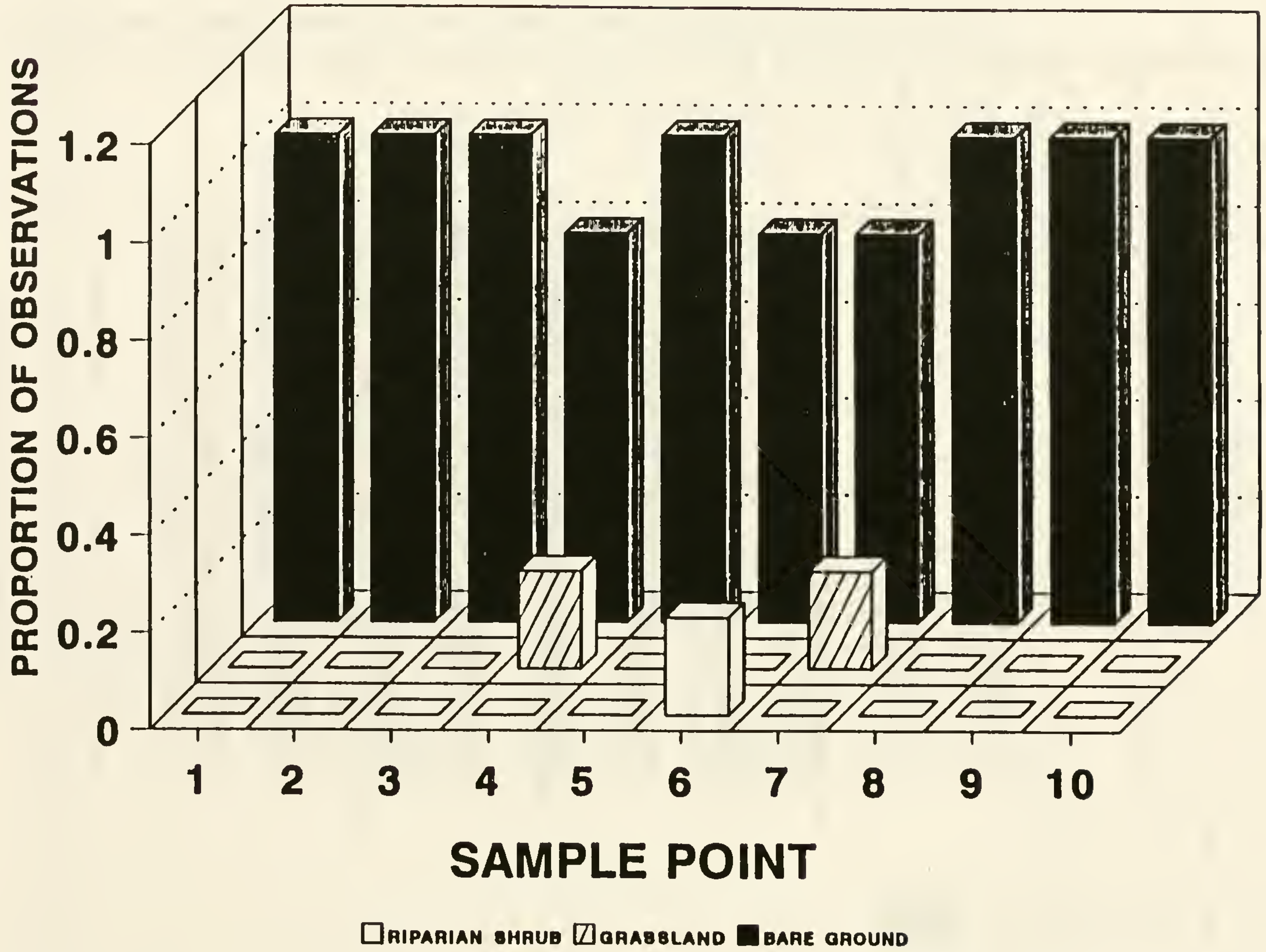

Figure 3-12. Proportional Representation of the Cover Types Encountered on the Opportunity Ponds.

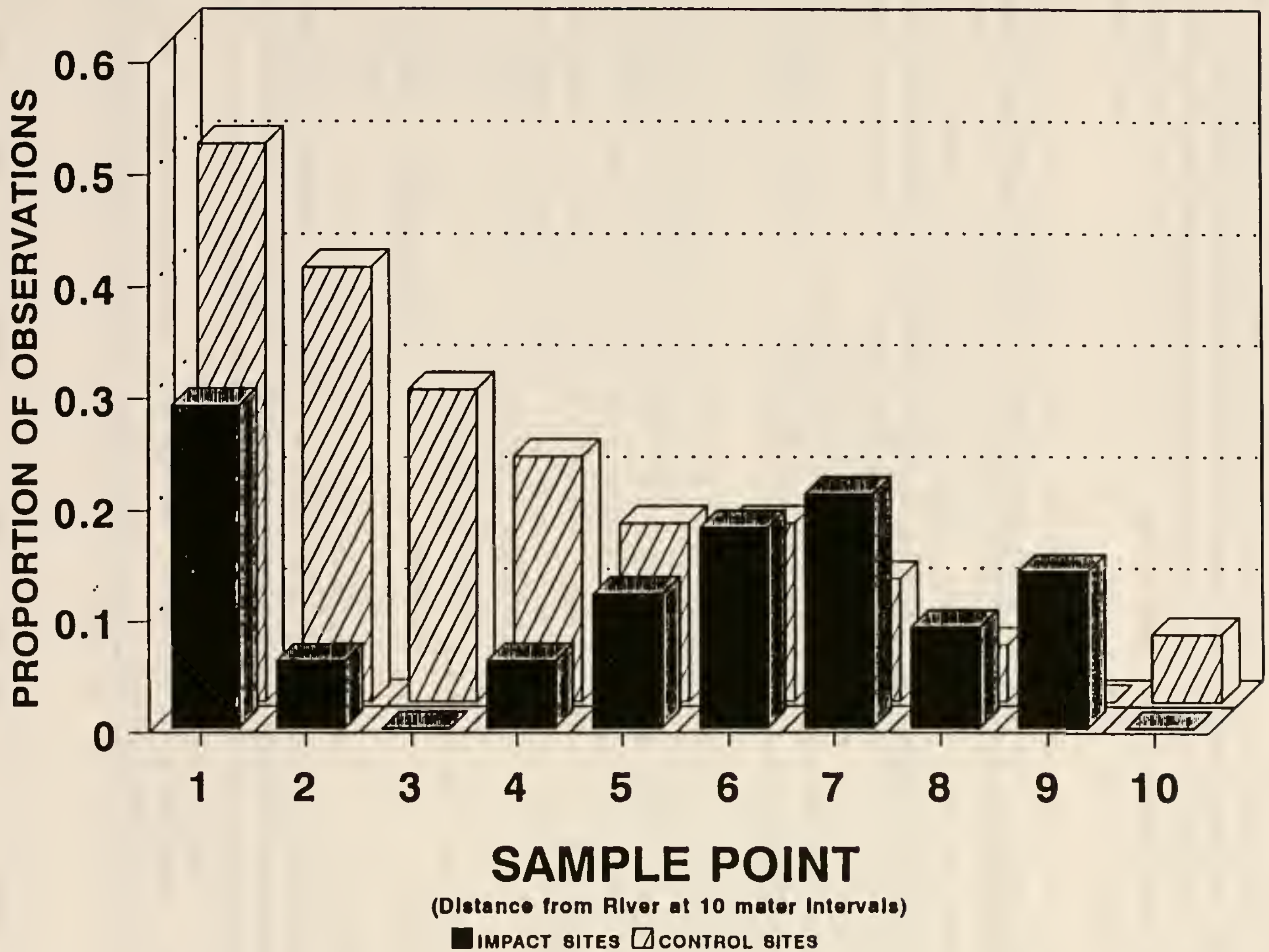

Figure 3-13. Comparison of the Proportional Representation of Riparian Shrub/Forest on Control and Impact Reaches.

Two-sample randomization tests were used to compare cover type proportional representations by reach. For example, the proportion of sample points on each transect in the upper Silver Bow Creek (n = 6 transects) reach classified as slickens was compared with the proportion of sample points on each transect in the Divide Creek (n = 6 transects) control reach classified as slickens. The results of these tests are presented in Table 3-14. Slickens have significantly greater proportional representation in all three of the impact reaches than in the control reaches. Riparian forest, hay and pasture have significantly greater proportional representation on the Little Blackfoot sites than on lower Silver Bow Creek sites. Hay and riparian shrub were present at significantly higher proportional representation on Flint Creek than on the upper Clark Fork River.

Table 3-14
Results of Two-Sample Randomization Tests Comparing Proportional Representation of Cover Types in Impact versus Control Areas

Area	Cover Type	p-Value
Upper Silver Bow vs. Divide Creek	Slickens	0.0014***
	Pasture	0.031**
Lower Silver Bow vs. Little Blackfoot	Slickens	0.0014***
	Hay	0.036*
	Pasture	0.046*
	Riparian shrub and forest	0.028**
Upper Clark Fork vs. Flint Creek	Slickens	0.002***
	Hay	0.018**
	Riparian shrub	0.03**

The p-values are the probabilities of the proportional representations of cover types being greater (hay, pasture, shrub and forest) or less (slickens) on the control areas due to chance.
* = Significant at $p < 0.05$
** = Significant at $p < 0.033$
*** = Significant at $p < 0.01$

3.3.2 Habitat Layers

The proportional representation of each habitat layer on impact and control transects, in relation to distance from the waters edge, is presented in Figures 3-14 and 3-15. From the waters edge up to 60 meters inland on the control reaches, tree canopy, tree bole, shrub midstory, understory, and terrestrial subsurface habitat layers were well represented. Beyond 60 meters, the tree canopy and bole layers were less well represented. In contrast, the habitat layers observed on impact reaches included primarily shrub midstory and understory. Tree canopy and terrestrial subsurface were represented only sporadically, while tree bole was not represented at all.

In the impact reaches, absence of all habitat layers was recorded at more than 60% of sample points; most layers that were observed were represented at less than 30% of sample points. In the control reaches, nearly 100% of sample points had understory and subsurface layers; 60%, declining gradually to 10% at 80-100 meters, of control sample points had a shrub midstory. These results were statistically analyzed using a Blocked One-way Analysis of Variance Randomization Test. Tree bole, understory and terrestrial subsurface each had significantly higher proportional representations on the control reaches than on the impact reaches ($p = 0.03$, 0.0002, and 0.0002, respectively), while tree canopy had a higher proportional representation on the control reaches ($p = 0.12$) than on the impact reaches.

Two-sample Randomization Tests were used to compare the proportional representation of habitat layers by reach (Table 3-15). All three control reaches individually had a significantly higher proportion of sample points at which understory and terrestrial subsurface were present when compared to their corresponding impact reaches. The Little Blackfoot had a significantly higher proportion of sites at which shrub midstory, tree canopy and tree bole were present than the corresponding lower Silver Bow Creek reach. On no impact reaches was there a significantly higher proportion of any habitat layer.

3.3.3 Numbers of Habitat Layers

Figures 3-16 and 3-17 present the proportional representations of numbers of habitat layers on control and impact transects. Control transects generally had between two and five layers close to the river bank, decreasing to two layers further from the river. This is a function of moving from an area with a high representation of a vertically diverse habitat (shrub/forest), to an area dominated by hay and pasture fields. In the control areas, the smallest number of habitat layers reported at any sample point was two. In contrast, in the impact area, absence of all habitat layers was the most common observation at all sample points. The greatest number of layers recorded for any sample point in the impact area was three.

Statistical analysis of these results was carried out using methods identical to those described for cover type and habitat layers above. The variable analyzed was the mean number of

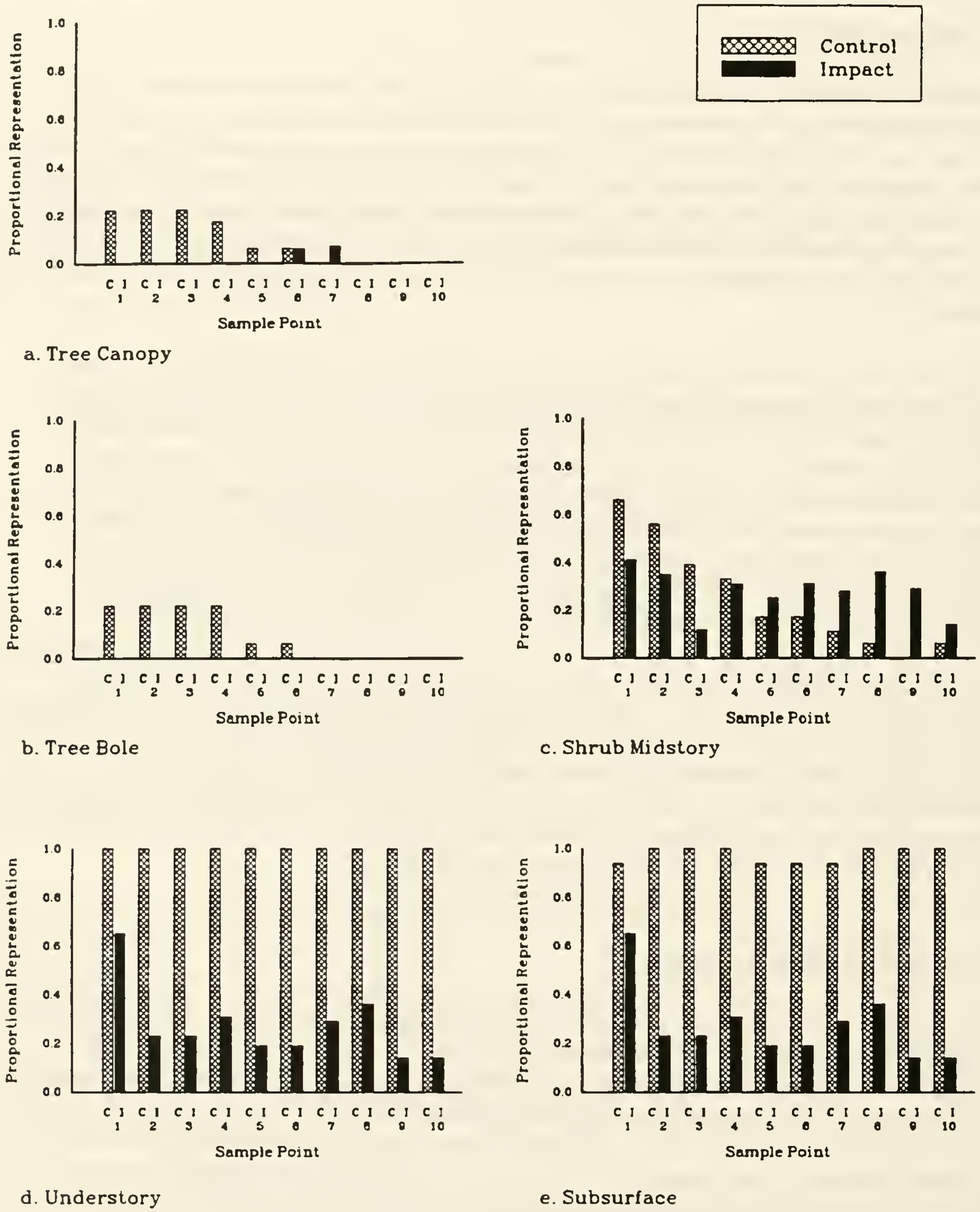

Figure 3-14. Proportional Representation of the Habitat Layers on Riparian Control (C) and Impact (I) Reaches. Sample points represent distance from the river at 10 meter intervals.

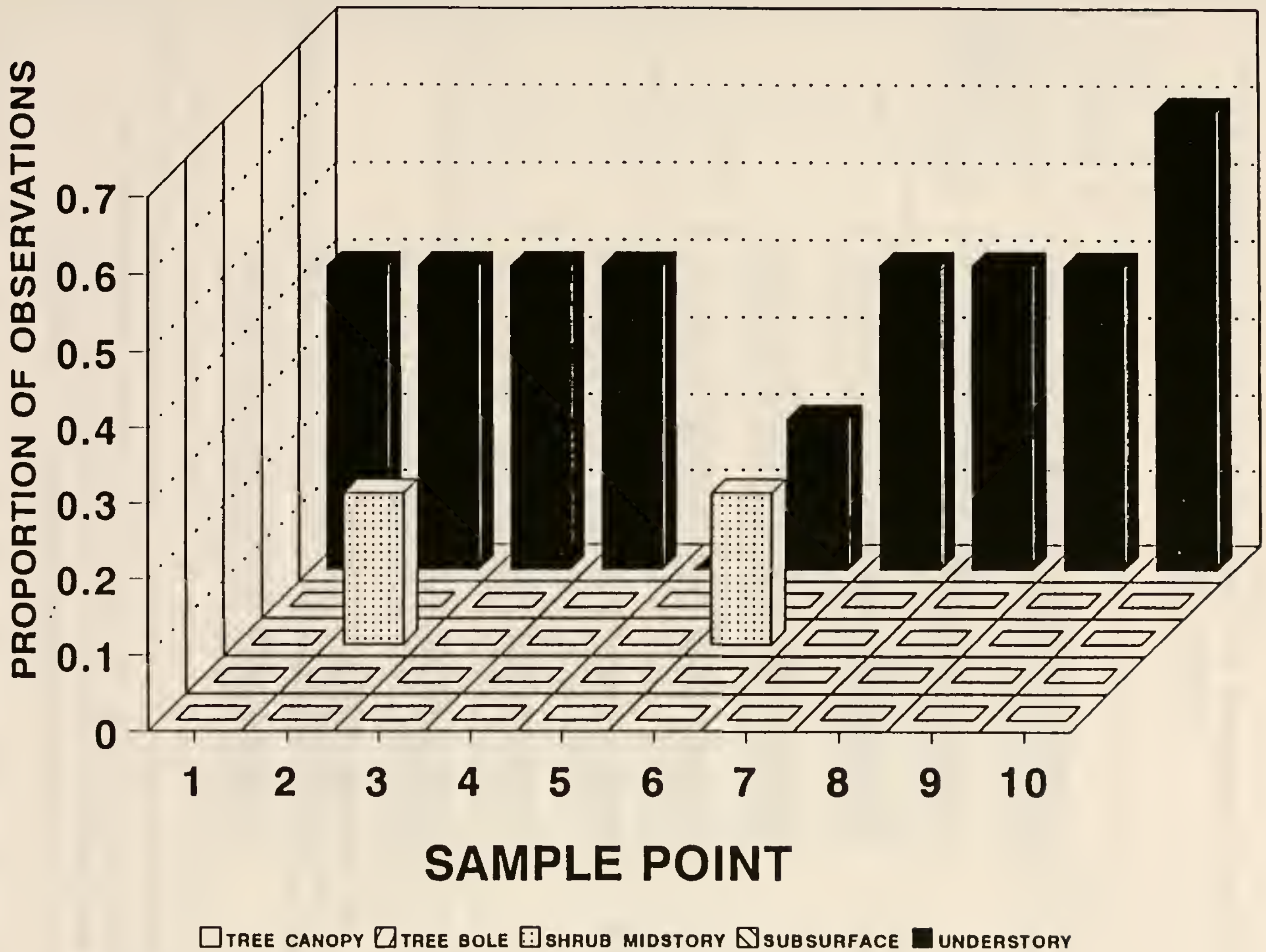

Figure 3-15. Proportional Representation of Habitat Layers on the Opportunity Ponds.

Table 3-15
Results of Two-Sample Randomization Tests Comparing Proportional Representation of Habitat Layers in Riparian Impact vs. Control Areas

Reach	Habitat Layers	p-Value
Upper Silver Bow Creek vs. Divide Creek	Understory	0.0012***
	Shrub Midstory	0.65
	Terrestrial subsurface	0.0012***
Lower Silver Bow vs. Little Blackfoot	Tree canopy	0.03**
	Tree bole	0.03**
	Shrub midstory	0.038*
	Understory	0.0012***
	Terrestrial subsurface	0.0018***
Upper Clark Fork vs. Flint Creek	Understory	0.002***
	Shrub Midstory	0.84
	Terrestrial subsurface	0.002***

The p-values are the probabilities of the proportional representations of habitat layers being greater in the control areas due to chance.
* = Significant at $p < 0.05$
** = Significant at $p < 0.033$
*** = Significant at $p < 0.01$.

layers/transect. A Blocked One-way Analysis of Variance Randomization Test showed a significantly higher mean number of habitat layers when all impact transects were compared with control transects ($p = 0.0002$). The results of Two-sample Randomization Tests comparing the mean number of layers reach by reach are shown in Table 3-16. Impact transects had significantly fewer layers when compared with control transects.

At Opportunity Ponds the most prevalent cover type (almost the only cover type) was bare ground (see Figure 3-12). No site had more than two habitat layers and approximately 80%

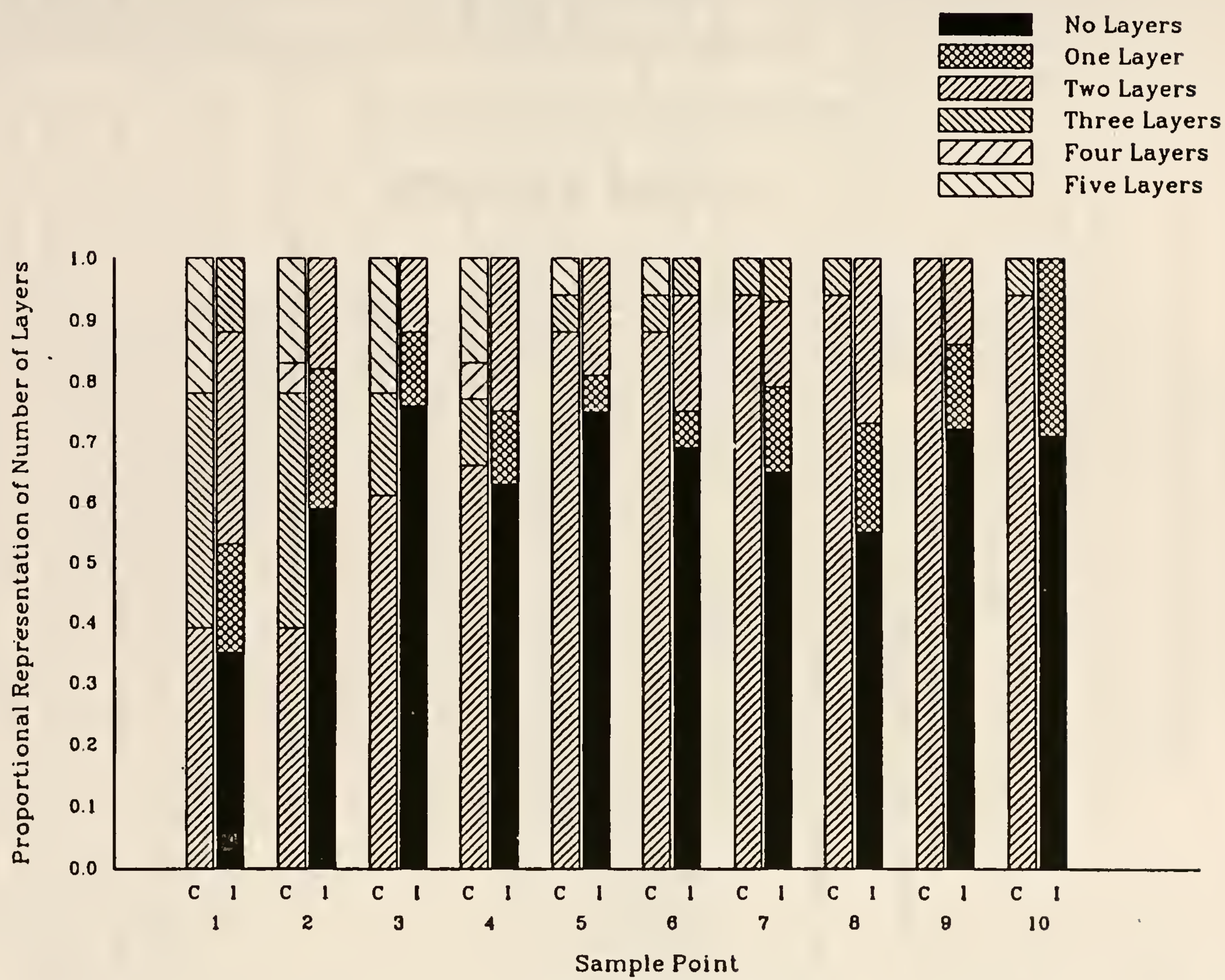

Figure 3-16. Proportional Representation of the Mean Number of Habitat Layers on Riparian Control (C) and Impact (I) Reaches. Sample points represent distance from the river at 10 meter intervals.

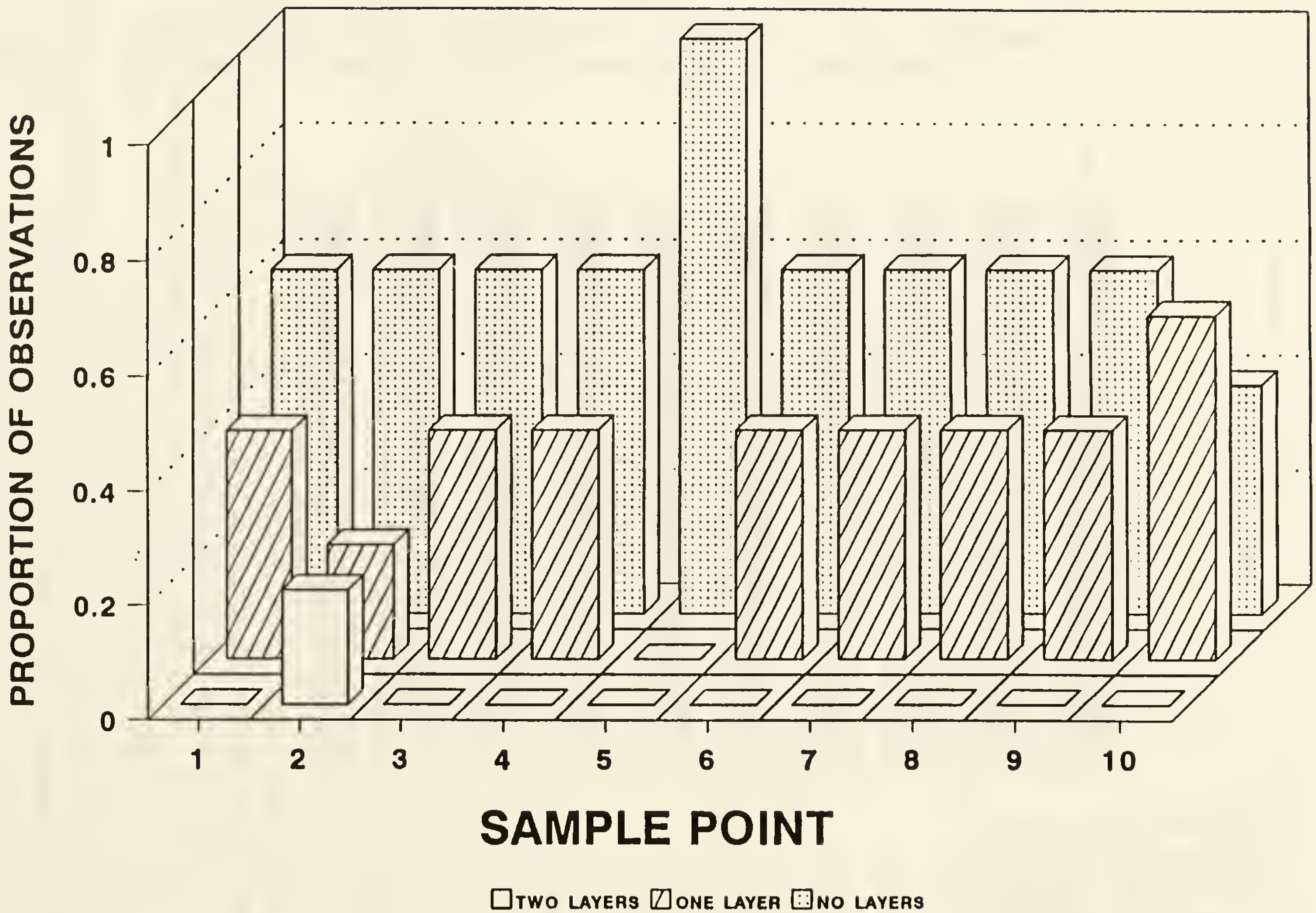

Figure 3-17. Proportional Representation of the Mean Number of Habitat Layers on the Opportunity Ponds.

Table 3-16
Results of Two-Sample Randomization Tests Comparing Mean Number of Habitat Layers in Riparian Impact versus Control Areas

Reach	p-Value (≤)
Upper Silver Bow Creek vs. Divide Creek	0.0012***
Lower Silver Bow Creek vs. Little Blackfoot River	0.001***
Upper Clark Fork River vs. Flint Creek	0.0028***

The p-values represent the probabilities that the greater mean number of layers observed on the control sites could be due to chance.
*** = Significant at $p < 0.01$.

of sample points had no habitat layers at all. There was no tree canopy or bole, little shrub midstory, no terrestrial subsurface, and only limited representation of understory. Two-sample Randomization Tests comparing the proportional representation of cover types on Opportunity Ponds vs. pooled riparian control areas showed a significantly higher representation of tailings on Opportunity Ponds ($p < 0.0002$), and a significantly lower representation of shrub/forest ($p < 0.05$), hay ($p < 0.08$) and pasture ($p < 0.06$). Two-sample Randomization Tests also showed a significantly lower mean number of habitat layers at Opportunity Ponds when compared with all control reaches ($p < 0.0002$).

3.4 RIPARIAN WILDLIFE

3.4.1 White-Tailed Deer Injury Determination

The proportions of sample points categorized as riparian shrub or forest habitat (i.e., cover), and those which had either "excellent," "good" or "fair" browse present are shown in Table 3-17. Figures 3-18 and 3-19 display the proportions of each of the slickens' transects classified as providing white-tailed deer cover or browse in relation to the transect (i.e., slickens) width. Slickens wider than approximately 150 meters have lower representations of cover and browse than narrower slickens. This relationship was tested for statistical significance using Two-sample Randomization Tests. Slickens greater than 150m in width had significantly lower representation of browse ($p = 0.04$) than the control areas.

Table 3-17
Results of White-Tailed Deer HEP Model: Cover and Browse

SITE	TREATMENT	NSAMPLES	NFOREST/ SHRUB	NBROWSE	pFOREST/ SHRUB	pBROWSE
SBC1	IMPACT	7	0	0	0	0
SBC2	IMPACT	3	0	0	0	0
SBC3	IMPACT	16	0	1	0	0.06
SBC4	IMPACT	11	1	4	0.09	0.36
SBC5	IMPACT	10	0	2	0	0.2
SBC6	IMPACT	12	5	6	0.42	0.5
				mean =	0.08	0.18
DC1	CONTROL	10	1	2	0.1	0.2
DC2	CONTROL	10	0	2	0	0.2
DC3	CONTROL	10	1	4	0.1	0.4
DC4	CONTROL	10	0	0	0	0
DC5	CONTROL	10	0	1	0	0.1
DC6	CONTROL	10	0	1	0	0.1
				mean =	0.04	0.17
SBC7	IMPACT	8	0	1	0	0.12
SBC8	IMPACT	6	1	2	0.17	0.33
SBC9	IMPACT	27	1	2	0.04	0.07
SBC10	IMPACT	18	0	2	0	0.11
SBC11	IMPACT	8	0	6	0	0.07
SBC12	IMPACT	8	0	1	0	0.12
				mean =	0.03	0.14
LBF1	CONTROL	12	2	4	0.17	0.33
LBF2	CONTROL	12	3	3	0.25	0.25
LBF3	CONTROL	12	6	7	0.5	0.6
LBF4	CONTROL	12	3	4	0.25	0.33
LBF5	CONTROL	10	1	2	0.1	0.16
LBF6	CONTROL	12	6	8	0.5	0.66
				mean =	0.29	0.39
CFR13	IMPACT	8	2	4	0.25	0.5
CFR14	IMPACT	7	2	2	0.28	0.3
CFR15	IMPACT	6	3	6	0.5	1
CFR16	IMPACT	7	2	3	0.28	0.4
CFR18	IMPACT	21	1	2	0.05	0.09
				mean =	0.27	0.46
FC1	CONTROL	10	2	2	0.2	0.2
FC2	CONTROL	10	4	4	0.4	0.4
FC3	CONTROL	8	8	8	1	1
FC4	CONTROL	10	0	0	0	0
FC5	CONTROL	10	0	1	0	0.1
FC6	CONTROL	10	0	1	0	0.1
				mean =	0.27	0.3
OP1	IMPACT	10	0	0	0	0
OP2	IMPACT	10	0	0	0	0
OP3	IMPACT	10	0	1	0	0.1
OP4	IMPACT	10	0	1	0	0.1
OP5	IMPACT	10	1	1	0.1	0.1
				mean =	0.02	0.06

SBC = Silver Bow Creek
DC = Divide Creek
LBF = Little Blackfoot River
CFR = Clark Fork River
FC = Flint Creek
OP = Opportunity Ponds

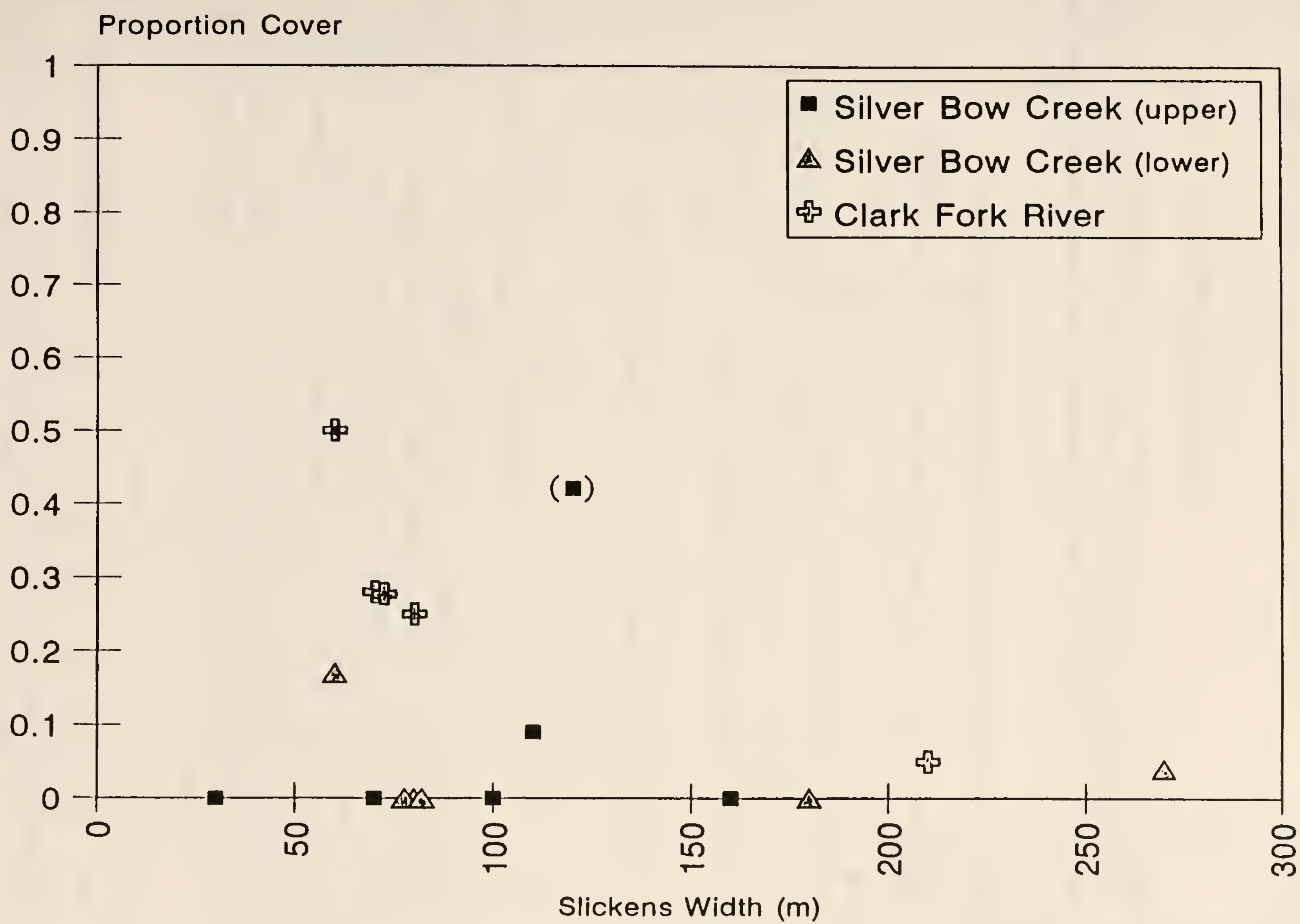

Figure 3-18. Proportional Representation of White-Tailed Deer Cover on Riparian Impact Transects.

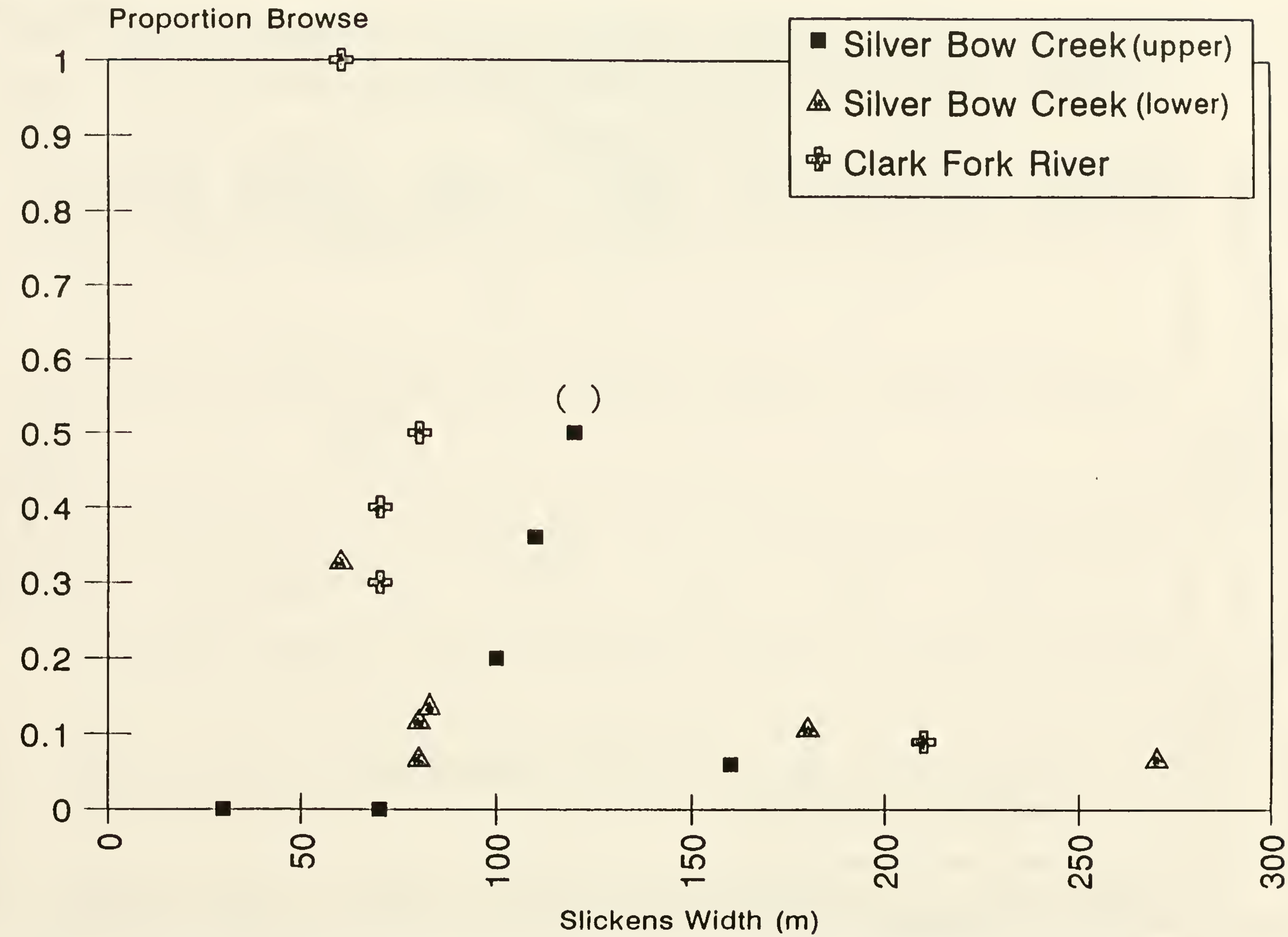

Figure 3-19. Proportional Representation of White-Tailed Deer Browse on Riparian Impact Transects.

Thus, slickens greater than 150m in width on the impact streams provided white-tailed deer habitat of significantly lower quality than the control transects.

3.4.2 Faunal Diversity Injury Determination

Comparison of the structural diversity of wildlife habitat on control and impact transects using a Blocked One-Way ANOVA Randomization Test (all impact vs. all control transects) and Two-Sample Randomization Tests (one-tailed) showed that slickens are significantly less diverse (Table 3-18) when:

- All impact transects are compared with all control transects ($p < 0.0002$).
- Upper Silver Bow Creek transects are compared with their controls (Divide Creek) ($p < 0.001$).
- Lower Silver Bow Creek transects are compared with their controls (Little Blackfoot River) ($p < 0.001$).
- Clark Fork River transects are compared with their controls (Flint Creek) ($p < 0.001$).
- Opportunity Ponds transects are compared with all control transects ($p < 0.0002$).

3.4.3 Faunal Diversity Injury Quantification

Tables 3-19 and 3-20 list bird and mammal species characteristic of riparian shrub and shrub/forest plant communities in southwest Montana, together with the habitat layers which they utilize when feeding, reproducing and avoiding disturbance. Populations of organisms dependent on tree canopy and tree bole are likely to have suffered the greatest injury from the almost complete removal of riparian forest that has occurred in the impact areas. Species that have likely suffered reduced viability and are likely to have become lost from the injured areas as a result of habitat loss are listed in Table 3-21. Other populations of riparian shrub and forest organisms less dependent on tree canopy and bole have likely suffered reduced viability due to the diminished representation of riparian shrub in the impact areas.

3.4.4 Riparian Bird Surveys

The two surveys of these bird populations showed that the densities of mergansers, great blue herons, belted kingfishers and dippers on the unimpacted Little Blackfoot River were

Table 3–18
Habitat Layers Data for Riparian Sites

Site	Treatment	Habitat Suitability Impact	Site	Treatment	Habitat Suitability Control	Impact/Control
SBC1	IMPACT	0	DC1	CONTROL	660	
SBC2	IMPACT	132	DC2	CONTROL	660	
SBC3	IMPACT	0	DC3	CONTROL	720	
SBC4	IMPACT	126	DC4	CONTROL	400	
SBC5	IMPACT	20	DC5	CONTROL	400	
SBC6	IMPACT	216	DC6	CONTROL	400	
		mean = 82.3			mean = 540	0.15
SBC7	IMPACT	98	LBF1	CONTROL	1495	
SBC8	IMPACT	33	LBF2	CONTROL	1375	
SBC9	IMPACT	60	LBF3	CONTROL	1750	
SBC10	IMPACT	22	LBF4	CONTROL	675	
SBC11	IMPACT	274	LBF5	CONTROL	1250	
SBC12	IMPACT	37	LBF6	CONTROL	675	
		mean = 87.3			mean = 1203	0.07
CFR13	IMPACT	372	FC1	CONTROL	660	
CFR14	IMPACT	148	FC2	CONTROL	1400	
CFR15	IMPACT	360	FC3	CONTROL	900	
CFR16	IMPACT	384	FC4	CONTROL	400	
CFR18	IMPACT	69	FC5	CONTROL	630	
			FC6	CONTROL	400	
		mean = 266.6			mean = 732	0.4
OP1	IMPACT	0				
OP2	IMPACT	30				
OP3	IMPACT	200				
OP4	IMPACT	0				
OP5	IMPACT	140	DC/LBF/FC	CONTROL		
		mean = 74			mean = 825	0.09

SBC=Silver Bow Creek; CFR=Clark Fork; DC=Divide Creek; LBF=Little Blackfoot; FC = Flint Creek; OP=Opportunity Ponds

Table 3-19
Birds Characteristic of Southwest Montana Riparian Shrub/Forest and Their Feeding and Nesting Vegetation Layers

Species		Feeding Layers	Nesting Layers
Great blue heron	*Ardea herodias*	-	TC
Mallard	*Anas platyrhynchos*	-	US
Common merganser	*Mergus merganser*	-	TB/US
Wood duck	*Aix sponsa*	-	TB
Osprey	*Pandion haliaetus*	-	TC
Bald eagle	*Haliaeetus leucocephalus*	-	TC
American kestrel	*Falco sparverius*	US	TC
Great-horned owl	*Bubo virginianus*	US/SM	TC/TB
Belted kingfisher	*Ceryle alcyon*	-	TS
Northern flicker	*Colaptes auratus*	TS/US	TB
Mourning dove	*Zenaida macroura*	US	TC/SM
Western wood-pewee	*Contopus sordidulus*	TC	TC
Willow flycatcher	*Empidonax traillii*	SM	SM
Eastern kingbird	*Tyrannus tyrannus*	TC	TC
Tree swallow	*Tachycineta bicolor*	-	TB
Bank swallow	*Riparia riparia*	-	TS
Black-billed magpie	*Pica pica*	US	TC/SM
Black-capped chickadee	*Parus atricapillus*	TC/US	TB
House wren	*Troglodytes aedon*	SM/US	TB
American robin	*Turdus migratorius*	US	TC/SM
Veery	*Catharus fuscescens*	SM	SM
European starling	*Sturnus vulgaris*	US	TB
Warbling vireo	*Vireo gilvus*	SM	SM
Yellow warbler	*Dendroica petechia*	SM	SM
American redstart	*Setophaga ruticilla*	SM/TC	SM/TC
Common yellowthroat	*Geothlypis trichas*	SM/US	SM/US
Song sparrow	*Melospiza melodia*	SM/US	SM/US
Red-winged blackbird	*Agelaius phoeniceus*	SM/US	SM
Brewer's blackbird	*Euphagus cyanocephalus*	US	SM
Black-headed grosbeak	*Pheucticus melanocephalus*	TC	SM
Brown-headed cowbird	*Molothrus ater*	US	TC/SM/US
Northern oriole	*Icterus galbula*	TC	TC

TC = Tree canopy
TB = Tree bole
SM = Shrub midstory
US = Understory
TS = Terrestrial subsurface.

References: Bergeron et al., 1992; Johnsgard, 1992.

Table 3-20
Mammals Characteristic of Southwest Montana Riparian Shrub/Forest and Their Feeding and Cover Vegetation Layers

Species		Feeding Layers	Cover Layers
Little brown bat	*Myotis lucifragus*	-	TB
Red fox	*Vulpes vulpes*	US	US/TS
Raccoon	*Procyon lotor*	US	TB/TC
Mink	*Mustela vison*	US	US
White-tailed Deer	*Odocoileus virginianus*	SM/US	SM
Moose	*Alces alces*	SM/US	SM

TC = Tree canopy
TB = Tree bole
SM = Shrub midstory
US = Understory
TS = Terrestrial subsurface.

Reference: Chapman and Feldhamer, 1982.

Table 3-21
Bird and Mammal Populations that are Likely to have been Lost or Suffered Reduced Population Viability Because of Reductions in Tree Canopy, Bole, Shrub Midstory, Understory and Terrestrial Subsurface Habitat Layers in Riparian Impact Areas

Reduced Viability	Lost Species
Mallard	Great blue heron
Common merganser	Wood duck
Willow flycatcher	American kestrel
Black-billed magpie	Osprey
American robin	Bald eagle
Warbling vireo	Tree swallow
Yellow warbler	Great horned owl
Veery	Belted kingfisher
Song sparrow	Northern flicker
Red-winged blackbird	Bank swallow
Brewer's blackbird	Western wood-pewee
Brown-headed cowbird	Eastern kingbird
Red fox	Black-capped chickadee
Raccoon	House wren
White-tailed deer	European starling
Mink	American redstart
Moose	Northern oriole
	Black-headed grosbeak
	Little brown bat

approximately 14 times greater than on Silver Bow Creek (Table 3-22). However, the densities of spotted sandpipers were approximately similar on both reaches. Great blue herons, mergansers and belted kingfishers are piscivores and dippers are benthivores. These birds obtain their food either from the water column or the river bottom. Spotted sandpipers, however, obtain most of their invertebrate prey from the river bank. This dietary difference explains why spotted sandpipers are able to maintain their population density along a river reach which (because of the impacts of hazardous substances to the fish and benthos) is unable to support healthy populations of the other species surveyed.

Table 3-22
Mean Numbers and Densities (Birds/River KM) of Birds Seen During Two Avian Surveys on Silver Bow Creek and the Little Blackfoot River Between Elliston and Avon

	Little Blackfoot		Silver Bow Creek	
	Mean Number	Mean Density	Mean Number	Mean Density
Common merganser	1*	0.2	0	0
Belted kingfisher	1	0.2	0	0
Great blue heron	1.5	0.2	1	0.1
Spotted sandpiper	7.5	1.5	7.5	1.1
Dipper	4.5	0.6	0	0
All species	15.5	2.7	8.5	1.2

* The merganser observation comprised an adult female bird with a brood of 7 ducklings.

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ATTACHMENT A

Elk HEP Model

ELK MODEL

1.0 INTRODUCTION

This document presents the results of a workshop convened to formulate an elk winter habitat model for the upper Clark Fork drainage basin of southwest Montana. A winter habitat model developed for elk wintering in the Blue Range Mountains of Oregon (Thomas et al., 1988) was used to provide a focus for discussions concerning winter habitat variables important to elk in the upper Clark Fork and their quantification. Although the model presented below utilizes some of the concepts and parameters presented in the Oregon model, it incorporates quantitative relationships specific to the upper Clark Fork River Basin area of Montana.

2.0 PURPOSE OF MODEL

The purpose of this model is to evaluate the suitability of elk winter habitat in impacted and control upland areas within the upper Clark Fork drainage. It expresses habitat suitability in terms of Habitat Suitability Indices (HSIs) for two habitat variables, as well as in terms of an overall Habitat Effectiveness (HE) index for an entire study area. These indices represent the *potential* carrying capacity of the habitat being assessed (USFWS, 1980).

3.0 MODEL VARIABLES

In this model, the HE value for any area of winter habitat is a function of the interaction of two variables:

- HE_c - *Cover Quantity and Quality*
- HE_f - *Forage Quantity and Quality*

Lyon (1983) established a numerical relationship between human disturbance (road density) and elk habitat utilization (suitability) in western Montana. This relationship was included as a variable in the Oregon elk model (Thomas et al., 1988). However, in the study areas which will be chosen for this application the possible effects of disturbance will be controlled for by ensuring that treatment and control areas are similar in their proximity to roads. For this reason, roads have not been included as a separate variable. If it is not possible to control for the influence of roads in the site selection process, their density will be included as a variable in the model.

HE_c: Cover, in the form of stands of conifers, is an important habitat variable for elk in Montana (Lyon, 1979; USFS, 1978). Such cover provides elk with shelter from severe winter

weather by reducing wind chill and snow depths. Cover may also confer benefits in terms of freedom from disturbance and reduced predation.

HE_f: Forage quantity and quality is a major limiting factor for elk during the winter (Wisdom et al., 1986; Thomas et al., 1988). The preferred diet of wintering elk in western Montana is comprised primarily of bunch grasses and browse (D. Hook, J. Lyon, L. Marcum, and T. Lonner, pers. comm; M. Frisina, in prep.) which grow mainly in open meadows interspersed among forest cover, or under relatively sparse forest cover. Ready access to such areas is a major determinant of habitat suitability.

These variables may not be the only factors which influence the suitability of a particular area for wintering elk. Other factors, such as predation or competition with other grazing animals, may also be important. However, it was the consensus of the workshop that the three variables described above are likely to be of greatest importance to elk in their winter range in the upper Clark Fork area. As such, they can be used to provide an estimate of the potential, or baseline, carrying capacity of habitat in that geographic area.

4.0 QUANTIFICATION OF THE MODEL VARIABLES

4.1 HE_c

In western Montana, cover for elk is provided mainly by coniferous trees. Since deciduous trees lose their leaves in winter, their capacity to provide cover is limited. The suitability of a stand of conifers is a function of tree height and canopy closure: taller, more densely packed trees with greater canopy closure are generally preferred to shorter, sparser stands. This relationship is probably a function of shallower snow accumulations, warmer temperatures and reduced wind chill under the former. In southwest Montana conifer stands of at least 20 feet in height are favored as cover by elk (T. Lonner, pers. comm.). Shorter stands are not utilized as much. In this model, stands of deciduous trees or of conifers less than 20 feet in height are considered to not provide viable cover.

The degree of canopy closure of coniferous trees is an important determinant of the cover value provided by forest stands of coniferous trees. It was the consensus of the workshop that canopy closures greater than 50% are likely to provide optimum cover habitat, while less well-developed canopy closures provide lower cover value. This relationship was quantified and incorporated into the model by categorizing canopy closures into five classes and assigning cover HSI values of between 0 and 1 to each (Figure 4-1). Closures greater than 50% constitute optimal cover habitat and score 1.0 on the HSI scale. Closures of less than 10% are of only marginal cover value and score 0.1. Closures of between 10% and 30%, and 31% - 50% are intermediate in their cover values and score 0.4 and 0.8, respectively.

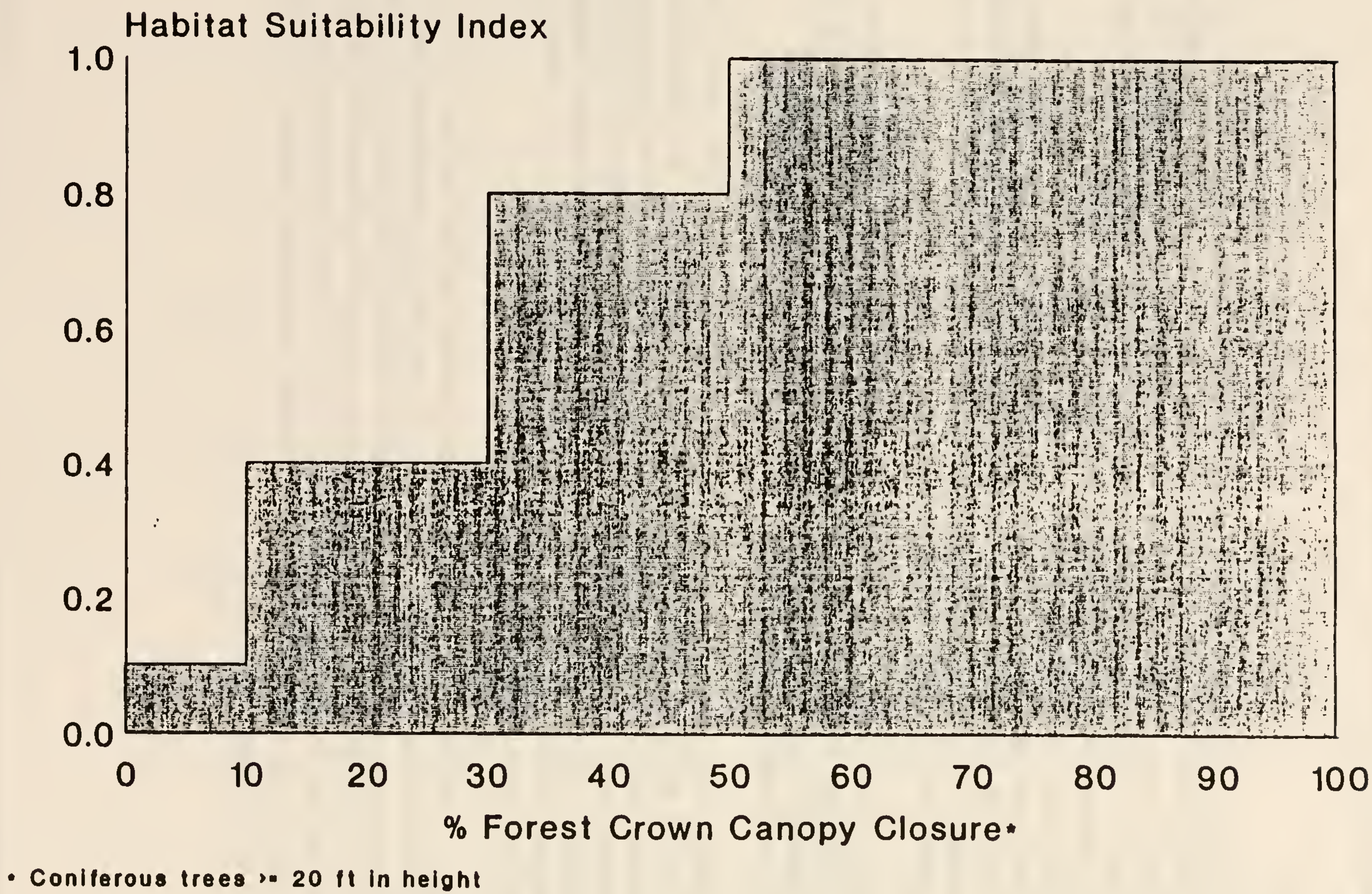

Figure 4-1. Relationship Between Forest Crown Canopy and Elk Winter Cover Habitat Suitability.

The HE_c value for the entire study area is the sum of the products of individual canopy closure HSIs and the proportion of the study area under each class.

4.2 HE_f

Using the relative forage values of plant species to Rocky Mountain elk during winter given in Kufeld (1973) and Thomas and Toweill (1982) and information contained in Mueggler and Stewart (1980), potential forage species were initially classified on the basis of the winter palatability to elk. Where necessary, these classifications were modified using local expert opinion and information (M. Frisina, pers. comm. and in prep.) to apply to the Butte/Anaconda area. The rankings comprise: "most valuable"; "less valuable"; "least valuable"; and "nonforage" species. Most valuable species generally scored value ratings of 2.25 in Thomas and Toweill (1982) and Kufeld (1973). Less valuable species had ranking values of between 1.5 and 2.25, and least valuable less than 1.5. Litter, rock, bare ground, and fallen timber was classified as nonforage.

Most valuable species include many bunch grasses and shrubby browse. Less valuable species include many forbs, while least valuable species include the surviving parts of rank weedy vegetation, coarse, unpalatable grasses, and low-growing vegetation likely to be inaccessible under snow during the winter.

The relationships between forage quantity and quality and the capacity of an area to provide winter habitat for elk in the upper Clark Fork are shown in Figure 4-2. It is assumed that the relationship between the forage value provided by an area of habitat and the percent ground cover of forage species is approximately linear. Forage species which are less valuable (i.e., not first choice for feeding elk) are assumed to be only half as palatable as most valuable species, and least valuable species are half as palatable as less valuable species. Nonforage is assumed to have no forage value.

The HE_f for a study area will be calculated by first sighting sampling quadrants or line intercepts in each of the cover classes present in the area and using the relationships shown in Figure 4-2 to arrive at a mean forage HSI for each cover class. The sum of the products of the proportion of the study area under each cover class and the mean forage HSI for each cover class will give the HEf for the entire study area. The forage HSI score for each sampling plot will be calculated as the sum of the HSIs for the highly valuable, less valuable and least valuable forage species.

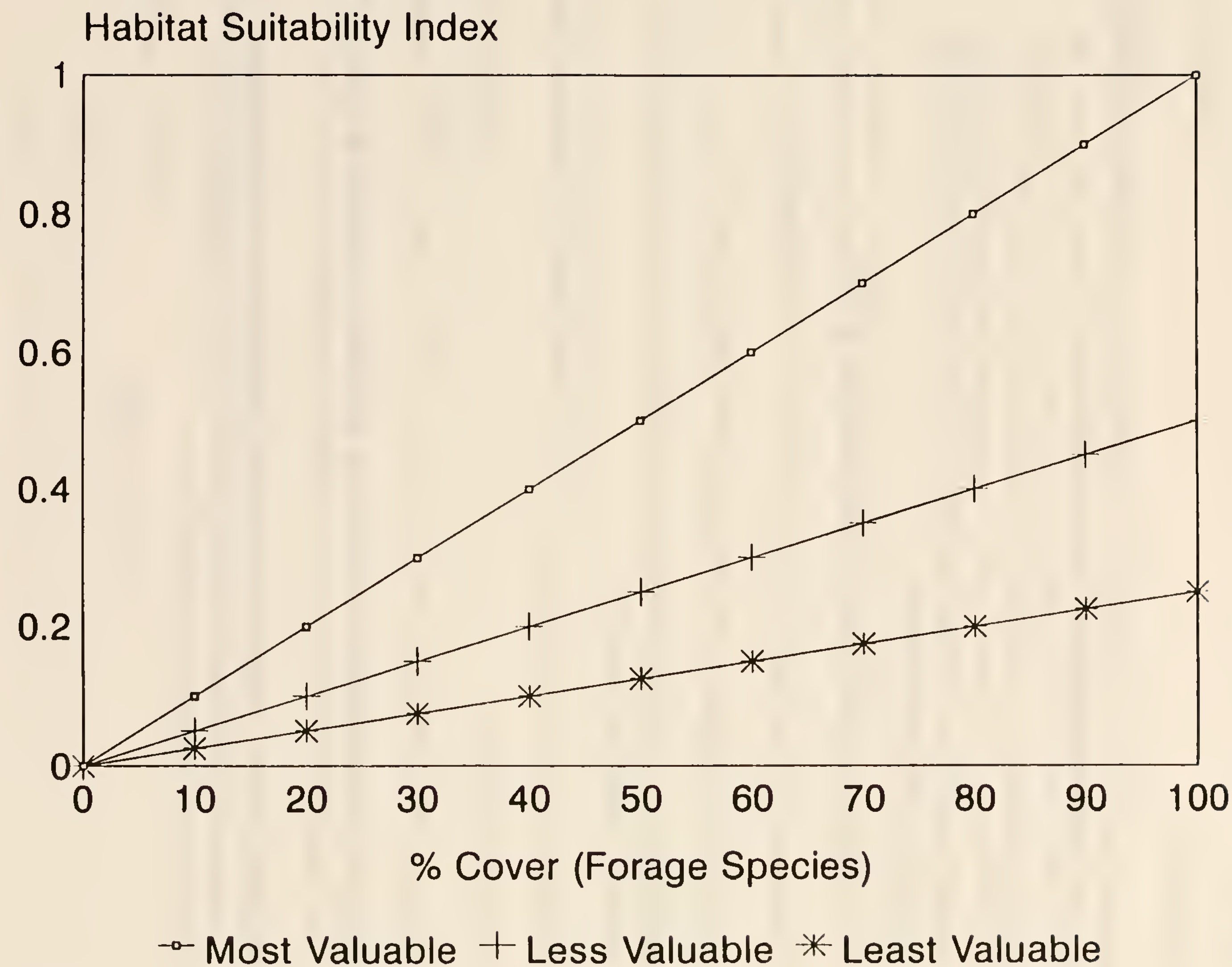

Figure 4-2. Relationship Between Forage and Elk Winter Habitat Suitability.

5.0 CALCULATING THE HABITAT EFFECTIVENESS (HE) INDEX OF A STUDY AREA

5.1 GENERAL

The cover and forage HSIs are calculated then combined in the overall Habitat Effectiveness (HE) Index for a study area using the following procedure:

1) Delineate the study area using maps, aerial photographs, and ground truthing.

2) Map the canopy closure (cc) classes (Figure 4-1) in the study area using aerial photographs and ground truthing.

3) Measure the proportion of the study area under each cc class.

4) Calculate the HE_c provided by the entire study area. This is given by:

   $(P_{>50\%cc} \times 1) + (P_{31\text{-}50\%cc} \times 0.8) + (P_{10\text{-}30\%cc} \times 0.4) + (P_{<10\%cc} \times 0.1)$

   Where P is the proportion of the study area under each cc class and the cover HSI values are taken from Figure 4-1.

5) Use Figure 4-2 and field sampling to obtain the mean forage HSI for each cc class.

6) Calculate HE_f from:

   $(P_{>50\%cc} \times HSI) + (P_{31\text{-}50\%cc} \times HSI) + (P_{10\text{-}30\%cc} \times HSI) + (P_{<10\%cc} \times HSI)$

   Where P is the proportion of the study area under each cc class and the HSIs are the mean forage HSI values (measured in the field) for cc class.

7) Study areas can be compared using their HE_c and HE_f values and by statistical comparison of their mean forage HSI values for each cc. Alternatively, an overall HE index for each study can be computed by:

$$HE = (HE_c \times HE_f)^{1/2}$$

5.2 EXAMPLES

5.2.1 Example A

Assumptions:

1) 40% of the study area is comprised of < 10%cc of coniferous forest, 10% is comprised of 10-30%, 25% is comprised of 31-50%cc, 25% is comprised of > 50%cc.

2) Field sampling showed that forage under < 10%cc scores 1.0, forage under 10-30%cc scores 0.8, forage under 31-50%cc scores 0.4, forage under > 50%cc scores 0.2.

This last assumption has a biological basis. The preferred forage of elk is open country grasses. These grasses tend not to achieve the same % cover under tree canopy.

Calculation of Variables:

- $HE_c = (0.4 \times 0.1) + (0.1 \times 0.4) + (0.25 \times 0.8) + (0.25 \times 1) = 0.53$
- $HE_f = (0.4 \times 1) + (0.1 \times 0.8) + (0.25 \times 0.4) + (0.25 \times 0.2) = 0.63$
- $HE = (0.53 \times 0.63)^{1/2} = 0.58$

5.2.2 Example B

Assumptions:

1) 90% of the study area is comprised of < 10%cc of coniferous forest, 5% is comprised of 10-30%cc, 5% is comprised of > 50%cc.

2) Field sampling showed that forage under < 10%cc scores 0.5, forage under 10-30%cc scores 0.4, forage under > 50%cc scores 0.2.

Calculation of Variables:

- $HE_c = (0.9 \times 0.1) + (0.05 \times 0.4) + (0.05 \times 1) = 0.16$
- $HE_f = (0.9 \times 0.5) + (0.05 \times 0.4) + (0.05 \times 0.2) = 0.5$
- $HE = (0.16 \times 0.5)^{1/2} = 0.28$

6.0 REFERENCES

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APPENDIX D

Results of 1994 Vegetation Sampling
in Anaconda Uplands, Southwest Montana

CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

This report describes the objectives, methods, and results of field sampling performed in the uplands near Anaconda, southwest Montana, during late September and early October 1994. Previous field measurements of vegetation community structure and composition made during July 1992 confirmed that the structure and composition of indigenous vegetation communities over an area of 17.8 square miles of uplands surrounding the Anaconda Smelter had been injured by releases of arsenic and metals (Lipton et al., 1995). This determination was based on measured differences in the structure and composition of vegetation communities at 21 paired sample sites in the injured area and in a nearby reference area (German Gulch). The 1992 study design and rationale is presented in Lipton et al. (1995).

The objectives of the sampling performed in the fall of 1994 were to:

- Provide, in conjunction with the 1992 data, a comprehensive evaluation of the spatial distribution of injured vegetation resources in the impact area, and, hence, aid restoration decisions.

- Evaluate temporal variability by determining whether data collected in 1994 support the conclusions arrived at in Lipton et al. (1995) concerning injuries to vegetation resources.

2.0 METHODS

Sample site selection and sampling methods followed the methodologies developed and utilized during the 1992 sampling (Lipton et al., 1995).

Sample Site Selection

The selection of sample sites was based on the Universal Transverse Mercator (UTM) Grid. Of the 40 grid intersections within the grossly injured area, 21 were sampled in 1992. The remaining 19 were sampled in 1994. In addition, 38 sample sites at the centers of the UTM grid cells were also sampled during 1994. These additional sampling locations were selected by drawing diagonal lines that connected opposite corners of the original grid cells and placing sampling sites at the intersections of the diagonals. A total of 57 impact sites were sampled in 1994, giving a total of 78 in both years combined. The locations of these sampling sites are shown in Figure 2-1. No control sites were sampled during 1994.

Sampling Methodology

As in 1992, each sample site comprised two 500 m transects intersecting at their midpoints on the UTM grid intersection and oriented along 345 or 165 degrees (the orientation of the UTM

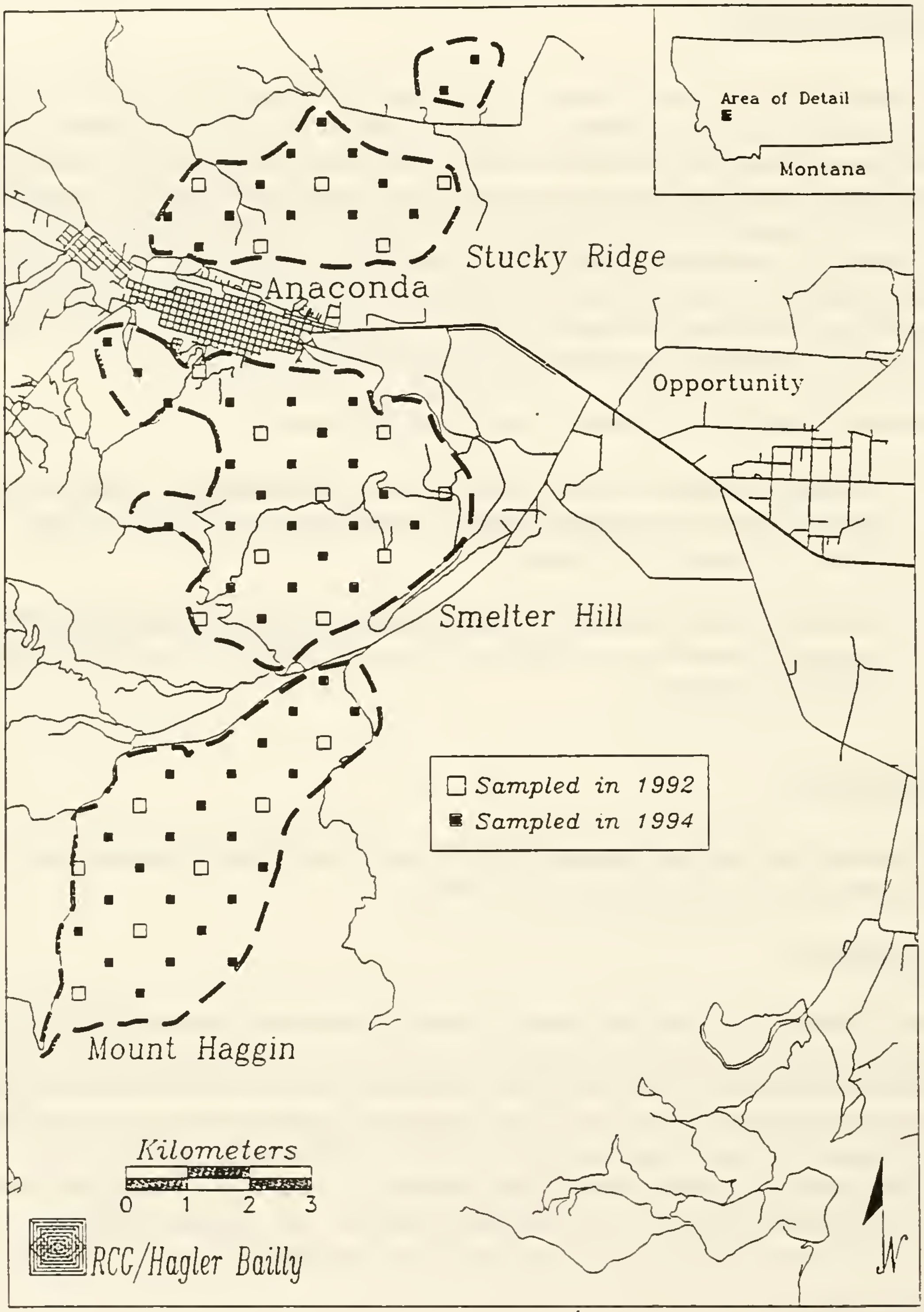

Figure 2-1. Locations of Impact Area Sample Sites in 1992 (open symbols), and in 1994 (closed symbols).

grid lines). Each transect had five sampling points at 100 m intervals, giving a total of 10 sampling points per site. At each sample point, vegetation measurements were made using two methods: visual estimation and line intercept measurement.

Visual Estimation

As in 1992, the following variables were recorded using visual estimation:

- The single most prevalent cover type within a 20 m radius.
- The presence or absence of previous afforestation (tree stumps, downed timber, standing dead timber).

In addition, if the main cover type was grassland, the dominant plant species was recorded. This measurement was not recorded in 1992.

Line Intercepts

The following variables were measured using 10 m line intercepts:

- The percent cover of living vegetation in the understory, shrub midstory, and tree canopy vegetation layers. Unlike 1992, the relative contributions by each plant species were not identified separately.
- The percent cover of nonliving material (plant litter, downed timber, rock, bare ground).

Statistical Analyses

Date were analyzed using t-tests with Satterthwaites correction for unequal variances (SAS Institute Inc., 1985).

3.0 RESULTS

The data obtained during fieldwork in 1994 are presented in Attachments A and B.

Cover Types

There were no significant differences in the proportional representations of cover types between the two years (Table 3-1). As in 1992, the most prevalent cover types in all three impact areas were bare ground and grassland. Whereas bare ground comprised approximately 40% of the cover types on Smelter Hill and Mount Haggin, it comprised almost 68% on

Table 3-1
Results of t-tests Comparing Cover Types Observed at Impact Sites in 1992 and 1994

Cover Types	Stucky Ridge p-Value	Smelter Hill p-Value	Mount Haggin p-Value	Combined p-Value
Evergreen forest	p = 0.3370	*	p = 0.3287	p = 0.1591
Deciduous forest	*	p = 0.8684	*	p = 0.8017
Evergreen shrubland	*	p = 0.4566	p = 0.7348	p = 0.7319
Deciduous shrubland	p = 0.9821	p = 0.3134	p = 0.6528	p = 0.6023
Grassland	p = 0.3664	p = 0.3931	p = 0.8611	p = 0.3388
Bare ground	p = 0.3621	p = 0.2319	p = 0.7004	p = 0.3179

* not observed at either 1992 or 1994 impact sites.

Stucky Ridge (Figure 3-1). This greater proportional representation of bare ground on Stucky Ridge is evident in the 1992 data also (Figure 3-1). Conversely, both the 1992 and 1994 data show that grassland had greater proportional representation on Smelter Hill and Mount Haggin than on Stucky Ridge (see below). At all sites combined, bare ground comprised 46% of the cover types and grassland almost 37%. Deciduous shrubland (mainly aspen (*Populus tremuloides*) stands) had only limited cover on all three impact areas, particularly on Stucky Ridge where it had a proportional representation of only about 6% (compared with 14% and 19% on Mount Haggin and Smelter Hill, respectively).

Grasslands

As in 1992, the 1994 measurements showed that grasslands were only sparsely vegetated (Figure 3-2). When all sites are combined, only 36% of the line intercepts were actually covered by vegetation, the remainder was mainly vegetative litter (27%), and bare ground (36%). Litter in the impact grassland areas studied did not resemble the deep vegetative litter that is normal for unimpacted grasslands or in forested areas elsewhere in southwest Montana, but was typically a shallow cover of dead plant material overlying bare ground. The extent of bare ground within the grassland community was most marked on Stucky Ridge (46% bare ground), followed by Smelter Hill (37% bare ground), and Mount Haggin (30% bare ground). In addition, measurements made in 1994 showed that the impact area grasslands were dominated by invasive weed species (i.e., early colonists of disturbed or stressed areas), rather

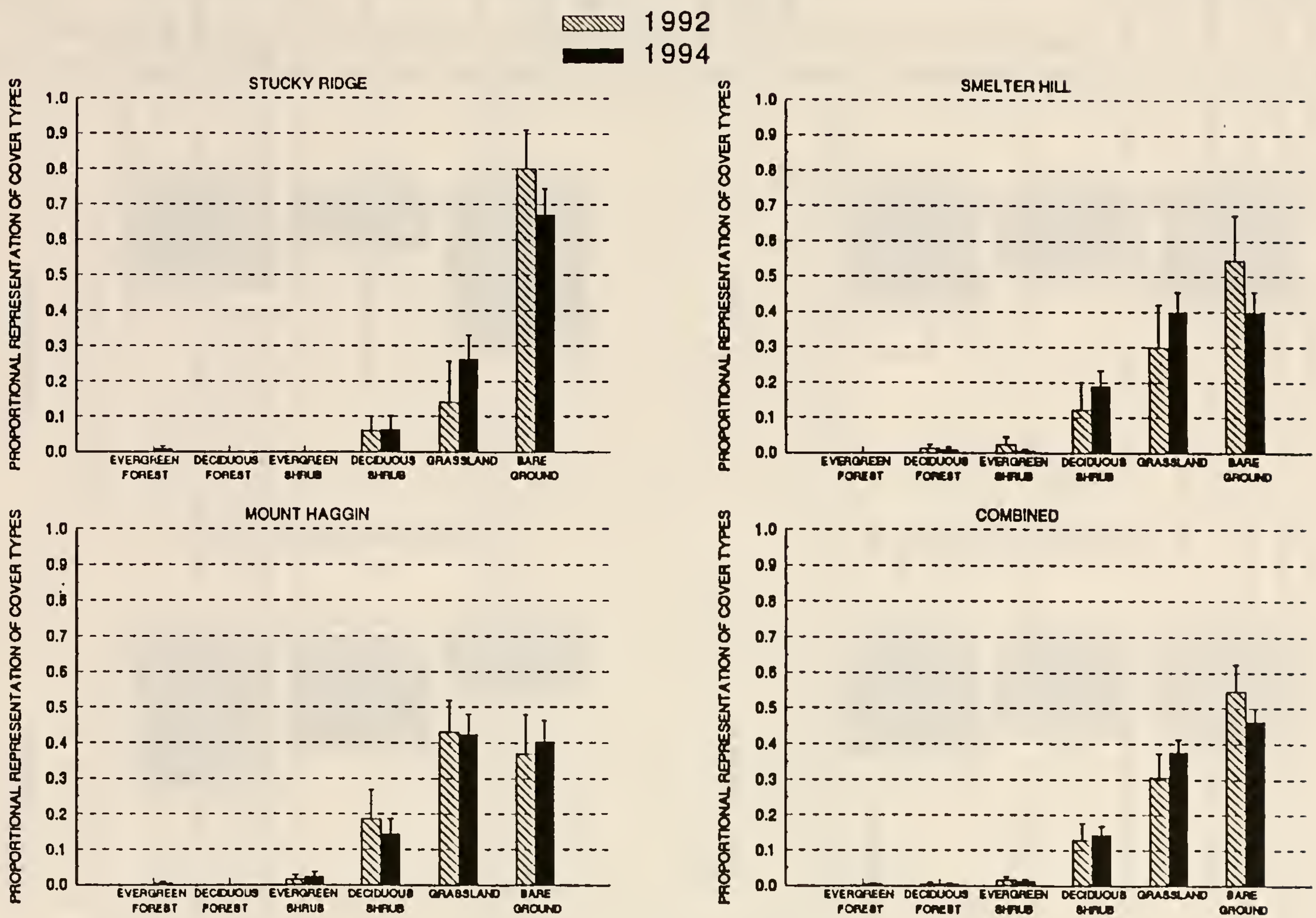

Figure 3-1. Comparisons of Proportional Representations of Cover Types in 1992 and 1994. (Mean proportional representation plus one standard error).

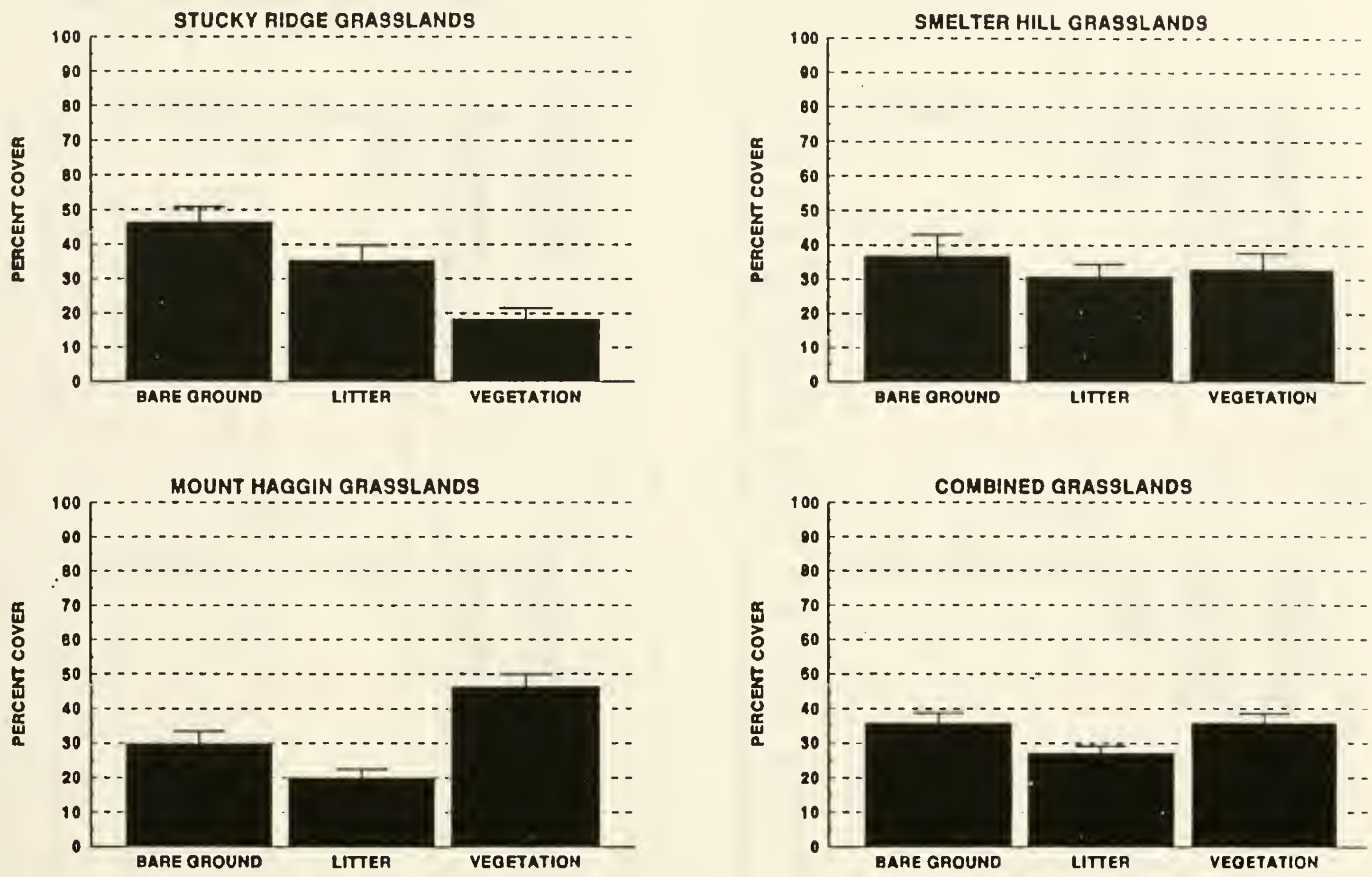

Figure 3-2. Mean Percent Cover (plus one standard error) of Bare Ground, Vegetation, and Plant Litter in Grassland in the Impact Area (1994 data only), as Determined by Line Intercept Measurements.

than plant species that are indigenous to grasslands in surrounding unimpacted areas (Table 3-2). Only 2.8% of grassland sites in the entire impact area were dominated by indigenous grass species. The remainder were dominated by invasive nongraminoid weeds (26%), or invasive graminoid species (69%), particularly redtop (*Agrostis stolonifera*), or Great Basin wild rye (*Elymus cinereus*). Most of those invasive species, particularly spotted knapweed (*Centaurea maculosa*), thistle (*Cirsium* spp.), and Great Basin wild rye are unpalatable to grazing animals, hence, of low forage value to wildlife.

Table 3-2
Proportional Representations (% of sites) of Dominant Species in Grassland Cover Type

	Invasive Species						
	Spotted Knapweed	Thistle	Redtop	Great Basin Wild Rye	Whitetop	Total Invasive Species	Native Species*
Stucky Ridge	36.6	30.1	21.9	5.2	6.2	100	0
Smelter Hill	26.8	0	42.1	21.9	0	90.8	5.9
Mount Haggin	0	0	84.9	14.3	0	99.2	0.8
Combined	18.8	6.35	53.5	15.6	1.3	95.6	2.8

* Native species include mainly bluebunch wheatgrass, Idaho fescue, and rough fescue.

Evidence of Previous Afforestation

Evidence of previous afforestation (tree stumps and dead timber) was found at 37 (65%) of the 57 sites sampled in 1994, indicating that, at least on the higher ground, much of the area designated as grossly injured once supported extensive conifer forest. No previously afforested sites were found on Stucky Ridge, however, one was found on the injured area to the north of Lost Creek. Figure 3-3 displays all sites (1992 and 1994) at which evidence of previous afforestation was found.

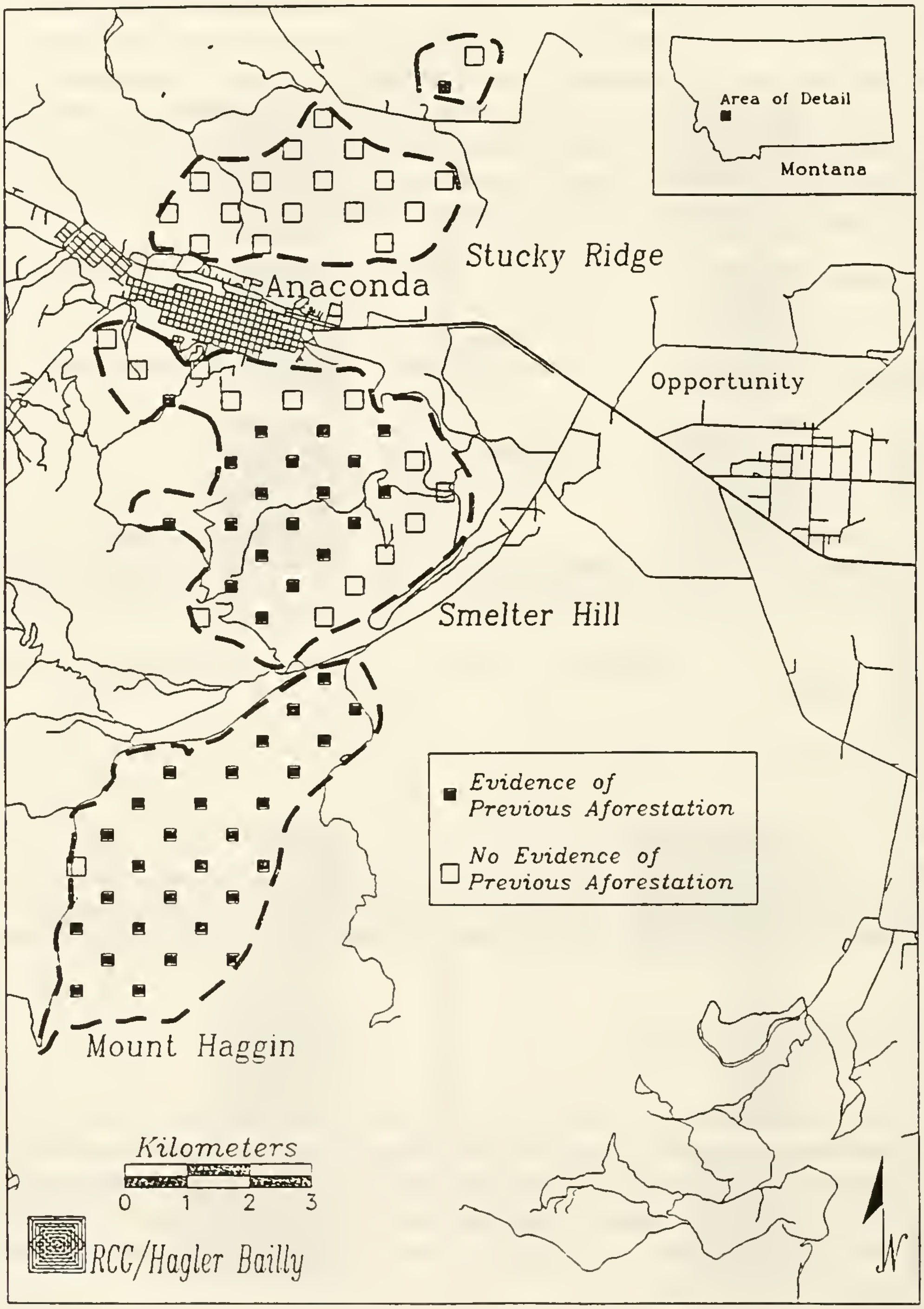

Figure 3-3. Sample Sites at which Evidence of Previous Afforestation was Found (1992 and 1994). (Closed symbols are those with evidence of previous afforestation, while open are those without.)

4.0 DISCUSSION

The results presented above confirm the conclusions derived from the 1992 sampling. These include:

- There has been a virtual eradication of conifer forest in the impact area, an area that previously supported extensive afforestation, particularly at the higher elevations on Smelter Hill and Mount Haggin. The 1994 results also support the 1992 conclusion that, prior to impact, Stucky Ridge was less afforested than the higher elevation sites and was probably a savanna-like landscape of grasslands with scattered trees. These trees, as at the present, probably were most frequent in the drainages. The conclusions regarding the extent of afforestation in the impact area drawn from the control sites are supported by the extent of the evidence of previous afforestation: 55% and 65% of sites, respectively.

- Grasslands in the impact area have been modified. In fact, the 1994 results confirm that much of the area categorized as "grassland" is not dominated by grass species, but by invasive nongraminoid weeds such as spotted knapweed, whitetop (*Cardaria draba*), and thistles. This is particularly so on Stucky Ridge where 73% of "grasslands" are actually virtual monocultures of knapweed or thistles. Even at those sites that are dominated by graminoids, the vegetation community differs markedly from indigenous grassland communities in southwest Montana. Such indigenous grassland communities in the German Gulch control area are generally dominated by native grasses including bluebunch wheat grass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), rough fescue (*Festuca scabrella*), and Sandberg's bluegrass (*Poa sandbergii*). In the impact area less than 3% of sites categorized as grassland were dominated by these species, the remainder of the sites that were true grasslands (predominantly vegetated by graminoids) were dominated by invasive species, particularly redtop and Great Basin wild rye. Much of the invasive vegetation that dominates the impact area grasslands is of low wildlife forage value, relative to the more palatable grasses that dominate unimpacted grasslands (Kufeld, 1973; Thomas and Toweill, 1982; Mueggler and Stewart, 1980).

- Deciduous shrubland (mainly aspen stands) is limited in distribution in the impact area. The 1992 and 1994 results were virtually identical at approximately 14% of sites sampled.

- The 1994 data confirm that evergreen forest and evergreen shrubland is limited in extent in the impact area (confined to less than 2% of sites sampled).

KEY

Line intercept no.	1 to 10 sample sites
Layer no.	1 = Tree canopy 2 = Shrub midstory 3 = Herbaceous layer
Cover type	0 = Out of sample area 1 = Evergreen forest 2 = Deciduous forest 3 = Evergreen shrublands 4 = Deciduous shrublands 5 = Grassland 6 = Bare ground 12 = Road 14 = Disturbed
Presence or absence of habitat layers	0 = absent 1 = present
No. of layers	Sum of habitat layers (tree canopy, tree bole, shrub midstory, understory, terrestrial subsurface)
Bare ground, litter, vegetation, fallen timber, rock line intercept measurement (percent of 10 meter intercept)	
Evidence of previous afforestation	0 = no 1 = yes

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence -- Previous Afforestation
A1	1	1	5	1	0	0	1	1	3	0	0	0	0	0	0
A1	1	2	5	1	0	0	1	1	3	0	0	0	0	0	0
A1	1	3	5	1	0	0	1	1	3	55	40	5	0	0	0
A1	2	1	5	0	0	0	1	1	2	0	0	0	0	0	0
A1	2	2	5	0	0	0	1	1	2	0	0	0	0	0	0
A1	2	3	5	0	0	0	1	1	2	50	40	10	0	0	0
A1	3	1	5	0	0	0	1	1	2	0	0	0	0	0	0
A1	3	2	5	0	0	0	1	1	2	0	0	0	0	0	0
A1	3	3	5	0	0	0	1	1	2	15	70	15	0	0	0
A1	4	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A1	4	2	5	0	0	0	1	0	1	0	0	0	0	0	0
A1	4	3	5	0	0	0	1	0	1	40	30	30	0	0	0
A1	5	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A1	5	2	5	0	0	0	1	0	1	0	0	0	0	0	0
A1	5	3	5	0	0	0	1	0	1	40	30	30	0	0	0
A1	6	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A1	6	2	5	0	0	0	1	0	1	0	0	0	0	0	0
A1	6	3	5	0	0	0	1	0	1	20	60	20	0	0	0
A1	7	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A1	7	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A1	7	3	6	0	0	0	1	0	1	100	0	0	0	0	0
A1	8	1	6	0	0	0	1	1	2	0	0	0	0	0	0
A1	8	2	6	0	0	0	1	1	2	0	0	0	0	0	0
A1	8	3	6	0	0	0	1	1	2	95	5	5	0	0	0
A7	1	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	1	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	1	3	6	0	0	0	1	0	1	95	5	5	0	0	0
A7	2	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	2	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	2	3	6	0	0	0	1	0	1	70	15	15	0	0	0
A7	3	1	4	0	0	1	1	0	2	0	0	0	0	0	0
A7	3	2	4	0	0	1	1	0	2	0	0	55	0	0	0
A7	3	3	4	0	0	1	1	0	2	25	45	30	0	0	0
A7	4	1	6	0	0	1	1	0	2	0	0	0	0	0	0
A7	4	2	6	0	0	1	1	0	2	0	0	0	0	0	0
A7	4	3	6	0	0	1	1	0	2	90	10	0	0	0	0
A7	5	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	5	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	5	3	6	0	0	0	1	0	1	85	10	5	0	0	0
A7	6	1	6	0	0	0	1	0	1	0	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
A7	6	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	6	3	6	0	0	0	1	0	1	90	5	5	0	0	0
A7	7	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	7	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	7	3	6	0	0	0	1	0	1	50	35	15	0	0	0
A7	8	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	8	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A7	8	3	6	0	0	0	1	0	1	90	0	10	0	0	0
A7	9	1	5	0	0	1	1	1	3	0	0	0	0	0	0
A7	9	2	5	0	0	1	1	1	3	0	0	0	0	0	0
A7	9	3	5	0	0	1	1	1	3	10	40	50	0	0	0
A7	10	1	5	0	0	0	1	1	2	0	0	0	0	0	0
A7	10	2	5	0	0	0	1	1	2	0	0	0	0	0	0
A7	10	3	5	0	0	0	1	1	2	50	30	20	0	0	0
A9	1	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A9	1	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A9	1	3	6	0	0	0	1	0	1	90	5	5	0	0	0
A9	2	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A9	2	2	5	0	0	0	1	0	1	0	0	0	0	0	0
A9	2	3	5	0	0	0	1	0	1	60	30	10	0	0	0
A9	3	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A9	3	2	5	0	0	0	1	0	1	0	0	0	0	0	0
A9	3	3	5	0	0	0	1	0	1	80	15	5	0	0	0
A9	4	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A9	4	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A9	4	3	6	0	0	0	1	0	1	90	5	5	0	0	0
A9	5	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A9	5	2	5	0	0	0	1	0	1	0	0	0	0	0	0
A9	5	3	5	0	0	0	1	0	1	40	60	0	0	0	0
A9	6	1	6	0	0	0	1	1	2	0	0	0	0	0	0
A9	6	2	6	0	0	0	1	1	2	0	0	0	0	0	0
A9	6	3	6	0	0	0	1	1	2	90	10	5	0	0	0
A9	7	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A9	7	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A9	7	3	6	0	0	0	0	0	0	80	5	15	0	0	0
A9	8	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A9	8	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A9	8	3	6	0	0	0	1	0	1	50	20	30	0	0	0
A9	9	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A9	9	2	6	0	0	0	1	0	1	0	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
A9	9	3	6	0	0	0	1	0	1	95	0	5	0	0	0
A9	10	1	6	0	0	0	1	1	2	0	0	0	0	0	0
A9	10	2	6	0	0	0	1	1	2	0	0	0	0	0	0
A9	10	3	6	0	0	0	1	1	2	70	20	10	0	0	0
A12	4	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A12	4	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A12	4	3	6	0	0	0	1	0	1	75	15	10	0	0	0
A12	5	1	4	0	0	1	1	0	2	0	0	0	0	0	0
A12	5	2	4	0	0	1	1	0	2	0	0	30	0	0	0
A12	5	3	4	0	0	1	1	0	2	80	10	5	5	0	0
A12	6	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A12	6	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A12	6	3	6	0	0	0	1	0	1	75	20	5	0	0	0
A12	7	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A12	7	2	5	0	0	0	1	0	1	0	0	0	0	0	0
A12	7	3	5	0	0	0	1	0	1	45	25	30	0	0	0
A12	8	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A12	8	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A12	8	3	6	0	0	0	1	0	1	85	5	10	0	0	0
A12	9	1	6	0	0	1	1	0	2	0	0	0	0	0	0
A12	9	2	6	0	0	1	1	0	2	0	0	0	0	0	0
A12	9	3	6	0	0	1	1	0	2	80	10	10	0	0	0
A12	10	1	6	0	0	1	1	0	2	0	0	0	0	0	0
A12	10	2	6	0	0	1	1	0	2	0	0	0	0	0	0
A12	10	3	6	0	0	1	1	0	2	70	20	10	0	0	0
A13	1	1	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	1	2	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	1	3	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	2	1	4	0	0	1	1	1	3	0	0	0	0	0	0
A13	2	2	4	0	0	1	1	1	3	0	0	0	0	0	0
A13	2	3	4	0	0	1	1	1	3	40	20	40	0	0	0
A13	5	1	5	0	0	1	1	1	3	0	0	0	0	0	0
A13	5	2	5	0	0	1	1	1	3	0	0	0	0	0	0
A13	5	3	5	0	0	1	1	1	3	40	45	15	0	0	0
A15	4	1	.	.	.	.	.	.	.	.	.	.	.	.	0
A15	4	2	.	.	.	.	.	.	.	.	.	.	.	.	0
A15	4	3	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	5	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A13	5	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A13	5	3	6	0	0	0	0	0	0	100	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
A13	6	1	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	6	2	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	6	3	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	7	1	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	7	2	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	7	3	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	8	1	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	8	2	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	8	3	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	9	1	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	9	2	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	9	3	.	.	.	.	.	.	.	.	.	.	.	.	0
A13	10	1	4	0	0	1	1	0	2	0	0	0	0	0	0
A13	10	2	4	0	0	1	1	0	2	0	0	0	0	0	0
A13	10	3	4	0	0	1	1	0	2	100	0	0	0	0	0
A14	1	1	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	1	2	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	1	3	5	0	0	0	1	1	2	35	43	20	0	0	0
A14	2	1	6	0	0	0	1	1	2	0	0	0	0	0	0
A14	2	2	6	0	0	0	1	1	2	0	0	0	0	0	0
A14	2	3	6	0	0	0	1	1	2	85	5	10	0	0	0
A14	3	1	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	3	2	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	3	3	5	0	0	0	1	1	2	45	30	25	0	0	0
A14	4	1	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	4	2	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	4	3	5	0	0	0	1	1	2	50	30	20	0	0	0
A14	5	1	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	5	2	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	5	3	5	0	0	0	1	1	2	50	30	20	0	0	0
A14	6	1	6	1	0	0	1	1	3	0	0	0	0	0	0
A14	6	2	6	1	0	0	1	1	3	0	0	0	0	0	0
A14	6	3	6	1	0	0	1	1	3	100	0	0	0	0	0
A14	7	1	5	0	0	1	1	1	3	0	0	0	0	0	0
A14	7	2	5	0	0	1	1	1	3	0	0	20	0	0	0
A14	7	3	5	0	0	1	1	1	3	70	25	5	0	0	0
A14	8	1	5	0	0	1	1	1	3	0	0	0	0	0	0
A14	8	2	5	0	0	1	1	1	3	0	0	5	0	0	0
A14	8	3	5	0	0	1	1	1	3	40	30	30	0	0	0
A14	9	1	6	0	0	0	1	0	1	0	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under–story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
A14	9	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A14	9	3	6	0	0	0	1	0	1	90	5	5	0	0	0
A14	10	1	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	10	2	5	0	0	0	1	1	2	0	0	0	0	0	0
A14	10	3	5	0	0	0	1	1	2	45	35	20	0	0	0
A15	1	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	1	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	1	3	6	0	0	0	1	0	1	90	10	0	0	0	0
A15	2	1	6	0	0	0	1	1	2	0	0	0	0	0	0
A15	2	2	6	0	0	0	1	1	2	0	0	0	0	0	0
A15	2	3	6	0	0	0	1	1	2	95	10	0	0	0	0
A15	3	1	6	0	0	0	1	1	2	0	0	0	0	0	0
A15	3	2	6	0	0	0	1	1	2	0	0	0	0	0	0
A15	3	3	6	0	0	0	1	1	2	95	5	5	0	0	0
A15	4	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	4	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	4	3	6	0	0	0	1	0	1	75	15	10	0	0	0
A15	5	1	6	0	0	1	1	0	2	0	0	0	0	0	0
A15	5	2	6	0	0	1	1	0	2	0	0	0	0	0	0
A15	5	3	6	0	0	1	1	0	2	100	0	0	0	0	0
A15	6	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	6	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	6	3	6	0	0	0	1	0	1	65	20	15	0	0	0
A15	7	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	7	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	7	3	6	0	0	0	1	0	1	75	20	5	0	0	0
A15	8	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	8	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	8	3	6	0	0	0	1	0	1	100	0	0	0	0	0
A15	9	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A15	9	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A15	9	3	6	0	0	0	0	0	0	100	0	0	0	0	0
A15	10	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	10	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A15	10	3	6	0	0	0	1	0	1	70	20	10	0	0	0
A16	1	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A16	1	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A16	1	3	6	0	0	0	0	0	0	90	5	5	0	0	0
A16	2	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A16	2	2	6	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
A16	2	3	6	0	0	0	0	0	0	70	10	30	0	0	0
A16	3	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	3	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	3	3	6	0	0	0	1	0	1	90	5	3	0	0	0
A16	4	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	4	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	4	3	6	0	0	0	1	0	1	90	5	5	0	0	0
A16	5	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	5	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	5	3	6	0	0	0	1	0	1	60	20	20	0	0	0
A16	6	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A16	6	2	3	0	0	0	1	0	1	0	0	0	0	0	0
A16	6	3	3	0	0	0	1	0	1	80	0	20	0	0	0
A16	7	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	7	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	7	3	6	0	0	0	1	0	1	100	0	0	0	0	0
A16	8	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	8	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A16	8	3	6	0	0	0	1	0	1	95	5	0	0	0	0
A16	9	1	5	0	0	1	1	0	2	0	0	0	0	0	0
A16	9	2	5	0	0	1	1	0	2	0	0	0	0	0	0
A16	9	3	5	0	0	1	1	0	2	65	30	5	0	0	0
A16	10	1	5	0	0	1	1	0	2	0	0	0	0	0	0
A16	10	2	5	0	0	1	1	0	2	0	0	0	0	0	0
A16	10	3	5	0	0	1	1	0	2	45	45	10	0	0	0
A17	1	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	1	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	1	3	6	0	0	0	0	0	0	70	0	30	0	0	0
A17	2	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	2	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	2	3	6	0	0	0	0	0	0	100	0	0	0	0	0
A17	3	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	3	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	5	3	6	0	0	0	0	0	0	100	0	0	0	0	0
A17	4	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A17	4	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A17	4	3	6	0	0	0	1	0	1	90	0	10	0	0	0
A17	5	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	5	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	5	3	6	0	0	0	0	0	0	100	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
A17	6	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	6	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	6	3	6	0	0	0	0	0	0	100	0	0	0	0	0
A17	7	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	7	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	7	3	6	0	0	0	0	0	0	100	0	0	0	0	0
A17	8	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A17	8	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A17	8	3	6	0	0	0	1	0	1	80	10	10	0	0	0
A17	9	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	9	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A17	9	3	6	0	0	0	0	0	0	65	35	0	0	0	0
A17	10	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A17	10	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A17	10	3	6	0	0	0	1	0	1	100	0	0	0	0	0
A18	1	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	1	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	1	3	6	0	0	0	1	0	1	85	10	5	0	0	0
A18	2	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	2	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	2	3	6	0	0	0	1	0	1	60	20	20	0	0	0
A18	3	1	6	0	0	0	1	1	2	0	0	0	0	0	0
A18	3	2	6	0	0	0	1	1	2	0	0	0	0	0	0
A18	3	3	6	0	0	0	1	1	2	30	40	30	0	0	0
A18	4	1	6	0	0	0	1	1	2	0	0	0	0	0	0
A18	4	2	6	0	0	0	1	1	2	0	0	0	0	0	0
A18	4	3	6	0	0	0	1	1	2	85	5	10	0	0	0
A18	5	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	5	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	5	3	6	0	0	0	1	0	1	75	20	5	0	0	0
A18	6	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	6	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	6	3	6	0	0	0	1	0	1	95	5	0	0	0	0
A18	7	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	7	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	7	3	6	0	0	0	1	0	1	60	25	15	0	0	0
A18	8	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	8	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	8	3	6	0	0	0	1	0	1	95	5	0	0	0	0
A18	9	1	6	0	0	0	1	0	1	0	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under–story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
A18	9	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	9	3	6	0	0	0	1	0	1	100	0	0	0	0	0
A18	10	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	10	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A18	10	3	6	0	0	0	1	0	1	40	30	30	0	0	0
A19	1	1	6	0	0	1	1	0	2	0	0	0	0	0	1
A19	1	2	6	0	0	1	1	0	2	0	0	5	0	0	1
A19	1	3	6	0	0	1	1	0	2	80	20	0	0	0	1
A19	2	1	6	0	0	1	0	0	1	0	0	0	0	0	1
A19	2	2	6	0	0	1	0	0	1	0	0	0	0	0	1
A19	2	3	6	0	0	1	0	0	1	100	0	0	0	0	1
A19	3	1	6	0	0	1	0	0	1	0	0	0	0	0	1
A19	3	2	6	0	0	1	0	0	1	0	0	5	0	0	1
A19	3	3	6	0	0	1	0	0	1	75	10	15	0	0	1
A19	4	1	6	0	0	1	0	0	1	0	0	0	0	0	1
A19	4	2	6	0	0	1	0	0	1	0	0	0	0	0	1
A19	4	3	6	0	0	1	0	0	1	90	10	0	0	0	1
A19	5	1	6	0	0	0	1	1	2	0	0	0	0	0	1
A19	5	2	6	0	0	0	1	1	2	0	0	0	0	0	1
A19	3	3	6	0	0	0	1	1	2	75	10	15	0	0	1
A19	6	1	6	0	0	1	0	0	1	0	0	0	0	0	1
A19	6	2	6	0	0	1	0	0	1	0	0	0	0	0	1
A19	6	3	6	0	0	1	0	0	1	100	0	0	0	0	1
A19	7	1	6	0	0	1	0	0	1	0	0	0	0	0	1
A19	7	2	6	0	0	1	0	0	1	0	0	0	0	0	1
A19	7	3	6	0	0	1	0	0	1	100	0	0	0	0	1
A19	8	1	1	1	1	1	1	1	5	.	.	.	.	.	1
A19	8	2	1	1	1	1	1	1	5	.	.	.	.	.	1
A19	8	3	1	1	1	1	1	1	5	.	.	.	.	.	1
A19	9	1	6	1	0	0	0	0	1	0	0	0	0	0	1
A19	9	2	6	1	0	0	0	0	1	0	0	0	0	0	1
A19	9	3	6	1	0	0	0	0	1	100	0	0	0	0	1
A19	10	1	5	0	0	1	1	0	2	0	0	0	0	0	1
A19	10	2	5	0	0	1	1	0	2	0	0	0	0	0	1
A19	10	3	5	0	0	1	1	0	2	30	65	5	0	0	1
A20	1	1	5	0	0	1	1	0	2	0	0	0	0	0	0
A20	1	2	5	0	0	1	1	0	2	0	0	0	0	0	0
A20	1	3	5	0	0	1	1	0	2	70	20	10	0	0	0
A20	2	1	6	0	0	1	1	0	2	0	0	0	0	0	0
A20	2	2	6	0	0	1	1	0	2	0	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
A20	2	3	6	0	0	1	1	0	2	80	15	5	0	0	0
A20	3	1	6	0	0	0	1	0	1	0	0	0	0	0	0
A20	3	2	6	0	0	0	1	0	1	0	0	0	0	0	0
A20	3	3	6	0	0	0	1	0	1	90	5	5	0	0	0
A20	4	1	6	0	0	1	1	0	2	0	0	0	0	0	0
A20	4	2	6	0	0	1	1	0	2	0	0	0	0	0	0
A20	4	3	6	0	0	1	1	0	2	80	10	10	0	0	0
A20	5	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A20	5	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A20	5	3	6	0	0	0	0	0	0	100	0	0	0	0	0
A20	6	1	6	0	0	1	1	0	2	0	0	0	0	0	0
A20	6	2	6	0	0	1	1	0	2	0	0	0	0	0	0
A20	6	3	6	0	0	1	1	0	2	90	5	5	0	0	0
A20	7	1	6	0	0	0	0	0	0	0	0	0	0	0	0
A20	7	2	6	0	0	0	0	0	0	0	0	0	0	0	0
A20	7	3	6	0	0	0	0	0	0	100	0	0	0	0	0
A20	8	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A20	8	2	5	0	0	0	1	0	1	0	0	0	0	0	0
A20	8	3	5	0	0	0	1	0	1	80	15	5	0	0	0
A20	9	1	5	0	0	0	1	0	1	0	0	0	0	0	0
A20	9	2	5	0	0	0	1	0	1	0	0	0	0	0	0
A20	9	3	5	0	0	0	1	0	1	60	10	30	0	0	0
A20	10	1	6	0	0	1	1	0	2	0	0	0	0	0	0
A20	10	2	6	0	0	1	1	0	2	0	0	0	0	0	0
A20	10	3	6	0	0	1	1	0	2	70	20	10	0	0	0
B1	1	1	4	0	0	1	1	1	3	0	0	0	0	0	0
B1	1	2	4	0	0	1	1	1	3	0	0	20	0	0	0
B1	1	3	4	0	0	1	1	1	3	5	45	50	0	0	0
B1	2	1	4	0	0	1	1	1	3	0	0	0	0	0	0
B1	2	2	4	0	0	1	1	1	3	0	0	20	0	0	0
B1	2	3	4	0	0	1	1	1	3	5	50	45	0	0	0
B1	3	1	5	0	0	1	1	1	3	0	0	0	0	0	0
B1	3	2	5	0	0	1	1	1	3	0	0	0	0	0	0
B1	3	3	5	0	0	1	1	1	3	5	35	60	0	0	0
B1	4	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B1	4	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B1	4	3	6	0	0	0	1	0	1	80	0	20	0	0	0
B1	5	1	5	0	0	1	1	1	3	0	0	0	0	0	0
B1	5	2	5	0	0	1	1	1	3	0	0	0	0	0	0
B1	5	3	5	0	0	1	1	1	3	0	40	60	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B1	6	1	5	0	0	1	1	1	3	0	0	0	0	0	0
B1	6	2	5	0	0	1	1	1	3	0	0	5	0	0	0
B1	6	3	5	0	0	1	1	1	3	5	45	50	0	0	0
B1	7	1	5	0	0	1	1	1	3	0	0	0	0	0	0
B1	7	2	5	0	0	1	1	1	3	0	0	5	0	0	0
B1	7	3	5	0	0	1	1	1	3	0	40	60	0	0	0
B1	8	1	4	0	0	1	1	1	3	0	0	0	0	0	0
B1	8	2	4	0	0	1	1	1	3	0	0	75	0	0	0
B1	8	3	4	0	0	1	1	1	3	5	70	25	0	0	0
B1	9	1	4	0	0	1	1	1	3	0	0	0	0	0	0
B1	9	2	4	0	0	1	1	1	3	0	0	10	0	0	0
B1	9	3	4	0	0	1	1	1	3	40	25	35	0	0	0
B1	10	1	4	0	0	1	1	1	3	0	0	0	0	0	0
B1	10	2	4	0	0	1	1	1	3	0	0	15	0	0	0
B1	10	3	4	0	0	1	1	1	3	0	75	25	0	0	0
B4	1	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B4	1	2	4	0	0	1	1	1	3	0	0	5	0	0	1
B4	1	3	4	0	0	1	1	1	3	75	15	10	0	0	1
B4	2	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B4	2	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B4	2	3	6	0	0	0	1	0	1	90	5	5	0	0	1
B4	3	1	5	0	0	0	1	0	1	0	0	0	0	0	1
B4	3	2	5	0	0	0	1	0	1	0	0	0	0	0	1
B4	3	3	5	0	0	0	1	0	1	75	15	15	0	0	1
B4	4	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B4	4	2	4	0	0	1	1	1	3	0	0	0	0	0	1
B4	4	3	4	0	0	1	1	1	3	30	50	20	0	0	1
B4	5	1	2	1	1	1	1	1	5	0	0	0	0	0	1
B4	5	2	2	1	1	1	1	1	5	0	0	55	0	0	1
B4	5	3	2	1	1	1	1	1	5	0	65	35	0	0	1
B4	6	1	6	0	0	0	1	1	2	0	0	0	0	0	1
B4	6	2	6	0	0	0	1	1	2	0	0	0	0	0	1
B4	6	3	6	0	0	0	1	1	2	45	40	15	0	0	1
B4	7	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B4	7	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B4	7	3	6	0	0	0	1	0	1	95	0	5	0	0	1
B4	8	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B4	8	2	4	0	0	1	1	1	3	0	0	50	0	0	1
B4	8	3	4	0	0	1	1	1	3	10	20	70	0	0	1
B4	9	1	4	0	0	1	1	1	3	0	0	0	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence -- Previous Afforestation
B4	9	2	4	0	0	1	1	1	3	0	0	25	0	0	1
B4	9	3	4	0	0	1	1	1	3	0	80	20	0	0	1
B4	10	1	6	0	0	0	1	1	2	0	0	0	0	0	1
B4	10	2	6	0	0	0	1	1	2	0	0	0	0	0	1
B4	10	3	6	0	0	0	1	1	2	70	15	15	0	0	1
B6	1	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B6	1	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B6	1	3	5	0	0	0	1	1	2	50	40	10	0	0	1
B6	2	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B6	2	2	4	0	0	1	1	1	3	0	0	65	0	0	1
B6	2	3	4	0	0	1	1	1	3	0	80	20	0	0	1
B6	3	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B6	3	2	4	0	0	1	1	1	3	0	0	20	0	0	1
B6	3	3	4	0	0	1	1	1	3	10	30	60	0	0	1
B6	4	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B6	4	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B6	4	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B6	5	1	4	0	0	1	1	0	2	.	.	.	.	.	1
B6	5	2	4	0	0	1	1	0	2	.	.	.	.	.	1
B6	5	3	4	0	0	1	1	0	2	.	.	.	.	.	1
B6	6	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B6	6	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B6	6	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B6	7	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B6	7	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B6	7	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B6	8	1	.	.	.	.	.	.	.	.	.	.	.	.	1
B6	8	2	.	.	.	.	.	.	.	.	.	.	.	.	1
B6	8	3	.	.	.	.	.	.	.	.	.	.	.	.	1
B6	9	1	5	0	0	0	1	1	2	.	.	.	.	.	1
B6	9	2	5	0	0	0	1	1	2	.	.	.	.	.	1
B6	9	3	5	0	0	0	1	1	2	.	.	.	.	.	1
B6	10	1	4	0	0	1	1	1	3	.	.	.	.	.	1
B6	10	2	4	0	0	1	1	1	3	.	.	.	.	.	1
B6	10	3	4	0	0	1	1	1	3	.	.	.	.	.	1
B10	1	1	5	0	0	1	1	1	3	0	0	0	0	0	1
B10	1	2	5	0	0	1	1	1	5	0	0	0	0	0	1
B10	1	3	5	0	0	1	1	1	3	70	20	10	0	0	1
B10	2	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B10	2	2	6	0	0	0	1	0	1	0	0	0	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B10	2	3	6	0	0	0	1	0	1	95	0	5	0	0	1
B10	3	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B10	3	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B10	3	3	6	0	0	0	1	0	1	95	5	0	0	0	1
B10	4	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B10	4	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B10	4	3	5	0	0	0	1	1	2	60	20	20	0	0	1
B10	5	1	5	0	0	0	1	0	1	0	0	0	0	0	1
B10	5	2	5	0	0	0	1	0	1	0	0	0	0	0	1
B10	5	3	5	0	0	0	1	0	1	60	20	20	0	0	1
B10	6	1	6	0	0	0	0	0	0	0	0	0	0	0	1
B10	6	2	6	0	0	0	0	0	0	0	0	0	0	0	1
B10	6	3	6	0	0	0	0	0	0	100	0	0	0	0	1
B10	7	1	6	0	0	0	0	0	0	0	0	0	0	0	1
B10	7	2	6	0	0	0	0	0	0	0	0	0	0	0	1
B10	7	3	6	0	0	0	0	0	0	95	0	0	5	0	1
B10	8	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B10	8	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B10	8	3	6	0	0	0	1	0	1	95	5	0	0	0	1
B10	9	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B10	9	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B10	9	3	5	0	0	0	1	1	2	100	0	0	0	0	1
B10	10	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B10	10	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B10	10	3	6	0	0	0	1	0	1	80	10	10	0	0	1
B12	1	1	6	0	0	0	0	0	0	0	0	0	0	0	0
B12	1	2	6	0	0	0	0	0	0	0	0	0	0	0	0
B12	1	3	6	0	0	0	0	0	0	95	0	5	0	0	0
B12	2	1	4	0	0	1	1	1	3	0	0	0	0	0	0
B12	2	2	4	0	0	1	1	1	3	0	0	65	0	0	0
B12	2	3	4	0	0	1	1	1	3	20	40	40	0	0	0
B12	3	1	4	0	0	1	1	1	3	0	0	0	0	0	0
B12	3	2	4	0	0	1	1	1	3	0	0	15	0	0	0
B12	3	3	4	0	0	1	1	1	3	0	55	45	0	0	0
B12	4	1	6	0	0	1	1	1	3	0	0	0	0	0	0
B12	4	2	6	0	0	1	1	1	3	0	0	0	0	0	0
B12	4	3	6	0	0	1	1	1	3	60	20	20	0	0	0
B14	1	1	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	1	2	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	1	3	.	.	.	.	.	.	.	.	.	.	.	.	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B14	2	1	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	2	2	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	2	3	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	3	1	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	3	2	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	3	3	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	4	1	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	4	2	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	4	3	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	5	1	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	5	2	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	5	3	.	.	.	.	.	.	.	.	.	.	.	.	1
B14	6	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B14	6	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B14	6	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B14	7	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B14	7	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B14	7	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B14	8	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B14	8	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B14	8	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B14	9	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B14	9	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B14	9	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B14	10	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B14	10	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B14	10	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B17	1	1	5	0	0	1	1	1	3	0	0	0	0	0	0
B17	1	2	5	0	0	1	1	1	3	0	0	0	0	0	0
B17	1	3	5	0	0	1	1	1	3	0	40	60	0	0	0
B17	2	1	5	0	0	0	1	1	2	0	0	0	0	0	0
B17	2	2	5	0	0	0	1	1	2	0	0	0	0	0	0
B17	2	3	5	0	0	0	1	1	2	0	45	55	0	0	0
B17	3	1	5	0	0	0	1	1	2	0	0	0	0	0	0
B17	3	2	5	0	0	0	1	1	2	0	0	0	0	0	0
B17	3	3	5	0	0	0	1	1	2	0	10	90	0	0	0
B17	4	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	4	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	4	3	5	0	0	0	1	0	1	60	25	15	0	0	0
B17	5	1	5	0	0	1	1	1	3	0	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B17	5	2	5	0	0	1	1	1	3	0	0	5	0	0	0
B17	5	3	5	0	0	1	1	1	3	0	40	60	0	0	0
B17	6	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	6	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	6	3	5	0	0	0	1	0	1	10	30	60	0	0	0
B17	7	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	7	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	7	3	5	0	0	0	1	0	1	15	25	60	0	0	0
B17	8	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	8	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	8	3	5	0	0	0	1	0	1	20	40	40	0	0	0
B17	9	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	9	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B17	9	3	5	0	0	0	1	0	1	25	25	50	0	0	0
B17	10	1	3	0	0	1	1	1	3	0	0	0	0	0	0
B17	10	2	3	0	0	1	1	1	3	0	0	10	0	0	0
B17	10	3	3	0	0	1	1	1	3	80	5	15	0	0	0
B19	1	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B19	1	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B19	1	3	5	0	0	0	1	1	2	20	20	60	0	0	1
B19	2	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B19	2	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B19	2	3	5	0	0	0	1	1	2	0	30	70	0	0	1
B19	3	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B19	3	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B19	3	3	5	0	0	0	1	1	2	10	30	60	0	0	1
B19	4	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B19	4	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B19	4	3	5	0	0	0	1	1	2	20	25	55	0	0	1
B19	5	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B19	5	2	4	0	0	1	1	1	3	0	0	0	0	0	1
B19	5	3	4	0	0	1	1	1	3	20	20	60	0	0	1
B19	6	1	5	0	0	1	1	0	2	0	0	0	0	0	1
B19	6	2	5	0	0	1	1	0	2	0	0	0	0	0	1
B19	6	3	5	0	0	1	1	0	2	15	35	60	0	0	1
B19	7	1	6	0	0	1	1	0	2	0	0	0	0	0	1
B19	7	2	6	0	0	1	1	0	2	0	0	0	0	0	1
B19	7	3	6	0	0	1	1	0	2	45	15	40	0	0	1
B19	8	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B19	8	2	6	0	0	0	1	0	1	0	0	0	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B19	8	3	6	0	0	0	1	0	1	85	15	0	0	0	1
B19	9	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B19	9	2	4	0	0	1	1	1	3	0	0	0	0	0	1
B19	9	3	4	0	0	1	1	1	3	25	20	55	0	0	1
B19	10	1	4	1	0	0	1	1	3	0	0	100	0	0	1
B19	10	2	4	1	0	0	1	1	3	0	0	0	0	0	1
B19	10	3	4	1	0	0	1	1	3	0	80	20	0	0	1
B20	1	1	5	0	0	0	1	0	1	0	0	0	0	0	1
B20	1	2	5	0	0	0	1	0	1	0	0	0	0	0	1
B20	1	3	5	0	0	0	1	0	1	30	50	20	0	0	1
B20	2	1	5	0	0	0	1	0	1	0	0	0	0	0	1
B20	2	2	5	0	0	0	1	0	1	0	0	0	0	0	1
B20	2	3	5	0	0	0	1	0	1	45	40	15	0	0	1
B20	3	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B20	3	2	4	0	0	1	1	1	3	0	0	60	0	0	1
B20	3	3	4	0	0	1	1	1	3	0	100	0	0	0	1
B20	4	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B20	4	2	4	0	0	1	1	1	3	0	0	50	0	0	1
B20	4	3	4	0	0	1	1	1	3	0	90	10	0	0	1
B20	5	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B20	5	2	4	0	0	1	1	1	3	0	0	50	0	0	1
B20	5	3	4	0	0	1	1	1	3	0	100	0	0	0	1
B20	6	1	2	1	1	1	1	1	5	0	0	0	0	0	1
B20	6	2	2	1	1	1	1	1	5	0	0	65	0	0	1
B20	6	3	2	1	1	1	1	1	5	0	80	20	0	0	1
B20	7	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B20	7	2	4	0	0	1	1	1	3	0	0	15	0	0	1
B20	7	3	4	0	0	1	1	1	3	0	75	25	0	0	1
B20	8	1	4	0	0	1	1	0	2	0	0	0	0	0	1
B20	8	2	4	0	0	1	1	0	2	0	0	20	0	0	1
B20	8	3	4	0	0	1	1	0	2	60	20	20	0	0	1
B20	9	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B20	9	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B20	9	3	6	0	0	0	1	0	1	65	15	20	0	0	1
B20	10	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B20	10	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B20	10	3	6	0	0	0	1	0	1	80	10	10	0	0	1
B21	1	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	1	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	1	3	6	0	0	0	1	0	1	90	0	5	5	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B21	2	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	2	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	2	3	6	0	0	0	1	0	1	65	15	20	0	0	1
B21	3	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	3	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	3	3	6	0	0	0	1	0	1	30	20	50	0	0	1
B21	4	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	4	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	4	3	6	0	0	0	1	0	1	50	10	25	15	0	1
B21	5	1	12	.	.	.	.	.	.	.	.	.	.	.	1
B21	5	2	12	.	.	.	.	.	.	.	.	.	.	.	1
B21	5	3	12	.	.	.	.	.	.	.	.	.	.	.	1
B21	6	1	5	0	0	1	1	1	3	0	0	0	0	0	1
B21	6	2	5	0	0	1	1	1	3	0	0	0	0	0	1
B21	6	3	5	0	0	1	1	1	3	50	25	25	0	0	1
B21	7	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	7	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B21	7	3	6	0	0	0	1	0	1	70	10	20	0	0	1
B21	8	1	12	.	.	.	.	.	.	.	.	.	.	.	1
B21	8	2	12	.	.	.	.	.	.	.	.	.	.	.	1
B21	8	3	12	.	.	.	.	.	.	.	.	.	.	.	1
B21	9	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B21	9	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B21	9	3	5	0	0	0	1	1	2	55	25	20	0	0	1
B21	10	1	5	0	0	1	1	1	3	0	0	0	0	0	1
B21	10	2	5	0	0	1	1	1	3	0	0	5	0	0	1
B21	10	3	5	0	0	1	1	1	3	60	40	0	0	0	1
B22	1	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B22	1	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B22	1	3	5	0	0	0	1	1	2	0	40	60	0	0	1
B22	2	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B22	2	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B22	2	3	6	0	0	0	1	0	1	65	5	25	5	0	1
B22	3	1	5	0	0	0	1	0	1	0	0	0	0	0	1
B22	3	2	5	0	0	0	1	0	1	0	0	0	0	0	1
B22	3	3	5	0	0	0	1	0	1	20	65	15	0	0	1
B22	4	1	5	0	0	0	1	0	1	0	0	0	0	0	1
B22	4	2	5	0	0	0	1	0	1	0	0	0	0	0	1
B22	4	3	5	0	0	0	1	0	1	30	50	20	0	0	1
B22	5	1	5	0	0	0	1	0	1	0	0	0	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B22	5	2	5	0	0	0	1	0	1	0	0	0	0	0	1
B22	5	3	5	0	0	0	1	0	1	20	60	20	0	0	1
B22	6	1	4	0	0	1	1	0	2	0	0	0	0	0	1
B22	6	2	4	0	0	1	1	0	2	0	0	60	0	0	1
B22	6	3	4	0	0	1	1	0	2	75	10	10	5	0	1
B22	7	1	5	0	0	1	1	1	3	0	0	0	0	0	1
B22	7	2	5	0	0	1	1	1	3	0	0	0	0	0	1
B22	7	3	5	0	0	1	1	1	3	0	0	90	10	0	1
B22	8	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B22	8	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B22	8	3	3	0	0	0	1	1	2	15	25	60	0	0	1
B22	9	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B22	9	2	4	0	0	1	1	1	3	0	0	30	0	0	1
B22	9	3	4	0	0	1	1	1	3	0	75	20	5	0	1
B22	10	1	3	0	0	0	1	1	2	0	0	0	0	0	1
B22	10	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B22	10	3	5	0	0	0	1	1	2	5	10	65	0	0	1
B23	1	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B23	1	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B23	1	3	6	0	0	0	1	0	1	80	10	10	0	0	1
B23	2	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B23	2	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B23	2	3	6	0	0	0	1	0	1	85	5	10	0	0	1
B23	3	1	4	0	0	1	1	0	2	0	0	0	0	0	1
B23	3	2	4	0	0	1	1	0	2	0	0	15	0	0	1
B23	3	3	4	0	0	1	1	0	2	80	10	0	0	0	1
B23	4	1	4	0	0	1	1	0	2	0	0	0	0	0	1
B23	4	2	4	0	0	1	1	0	2	0	0	10	0	0	1
B23	4	3	4	0	0	1	1	0	2	65	10	25	0	0	1
B23	5	1	6	0	0	1	1	0	2	0	0	0	0	0	1
B23	5	2	6	0	0	1	1	0	2	0	0	10	0	0	1
B23	5	3	6	0	0	1	1	0	2	65	20	15	0	0	1
B23	6	1	6	0	0	1	1	0	2	0	0	0	0	0	1
B23	6	2	6	0	0	1	1	0	2	0	0	5	0	0	1
B23	6	3	6	0	0	1	1	0	2	85	0	0	15	0	1
B23	7	1	6	0	0	0	0	0	0	0	0	0	0	0	1
B23	7	2	6	0	0	0	0	0	0	0	0	0	0	0	1
B23	7	3	6	0	0	0	0	0	0	100	0	0	0	0	1
B23	8	1	4	0	0	1	1	0	2	0	0	0	0	0	1
B23	8	2	4	0	0	1	1	0	2	0	0	20	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B23	8	3	4	0	0	1	1	0	2	30	20	30	0	0	1
B23	9	1	6	0	0	0	0	0	0	0	0	0	0	0	1
B23	9	2	6	0	0	0	0	0	0	0	0	0	0	0	1
B23	9	3	6	0	0	0	0	0	0	100	0	0	0	0	1
B23	10	1	6	0	0	0	0	0	0	0	0	0	0	0	1
B23	10	2	6	0	0	0	0	0	0	0	0	0	0	0	1
B23	10	3	6	0	0	0	0	0	0	90	0	0	10	0	1
B24	1	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B24	1	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B24	1	3	5	0	0	0	1	0	1	0	60	40	0	0	0
B24	2	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B24	2	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B24	2	3	5	0	0	0	1	0	1	5	70	25	0	0	0
B24	3	1	4	0	0	1	1	0	2	0	0	0	0	0	0
B24	3	2	4	0	0	1	1	0	2	0	0	0	0	0	0
B24	3	3	4	0	0	1	1	0	2	45	35	20	0	0	0
B24	4	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B24	4	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B24	4	3	6	0	0	0	1	0	1	45	30	25	0	0	0
B24	5	1	4	0	0	1	1	1	3	0	0	0	0	0	0
B24	5	2	4	0	0	1	1	1	3	0	0	45	0	0	0
B24	5	3	4	0	0	1	1	1	3	0	90	10	0	0	0
B24	6	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B24	6	2	5	0	0	0	1	0	1	0	0	35	0	0	0
B24	6	3	5	0	0	0	1	0	1	0	90	10	0	0	0
B24	7	1	4	0	0	1	1	0	2	0	0	0	0	0	0
B24	7	2	4	0	0	1	1	0	2	0	0	0	0	0	0
B24	7	3	4	0	0	1	1	0	2	75	10	15	0	0	0
B24	8	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B24	8	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B24	8	3	6	0	0	0	1	0	1	100	0	0	0	0	0
B24	9	1	5	0	0	1	1	0	2	0	0	0	0	0	0
B24	9	2	5	0	0	1	1	0	2	0	0	0	0	0	0
B24	9	3	5	0	0	1	1	0	2	10	55	35	0	0	0
B24	10	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B24	10	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B24	10	3	5	0	0	0	1	0	1	0	50	50	0	0	0
B26	1	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B26	1	2	4	0	0	1	1	1	3	0	0	0	0	0	1
B26	1	3	4	0	0	1	1	1	3	5	60	30	5	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B26	2	1	4	0	0	1	1	1	3	0	0	0	0	0	1
B26	2	2	4	0	0	1	1	1	3	0	0	5	0	0	1
B26	2	3	4	0	0	1	1	1	3	30	50	20	0	0	1
B26	3	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B26	3	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B26	3	3	6	0	0	0	1	0	1	95	5	0	0	0	1
B26	4	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B26	4	2	5	0	0	0	1	1	2	0	0	5	0	0	1
B26	4	3	5	0	0	0	1	1	2	65	30	5	0	0	1
B26	5	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B26	5	2	5	0	0	0	1	1	2	0	0	30	0	0	1
B26	5	3	5	0	0	0	1	1	2	60	30	10	0	0	1
B26	6	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B26	6	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B26	6	3	5	0	0	0	1	1	2	0	70	30	0	0	1
B26	7	1	6	0	0	1	1	0	2	0	0	0	0	0	1
B26	7	2	6	0	0	1	1	0	2	0	0	0	0	0	1
B26	7	3	6	0	0	1	1	0	2	85	10	5	5	0	1
B26	8	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B26	8	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B26	8	3	5	0	0	0	1	1	2	50	40	10	0	0	1
B26	9	1	5	0	0	0	1	0	1	0	0	0	0	0	1
B26	9	2	5	0	0	0	1	0	1	0	0	0	0	0	1
B26	9	3	5	0	0	0	1	0	1	60	20	20	0	0	1
B26	10	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B26	10	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B26	10	3	6	0	0	0	1	0	1	65	20	15	0	0	1
B27	1	1	5	0	0	0	1	1	2	0	0	0	0	0	1
B27	1	2	5	0	0	0	1	1	2	0	0	0	0	0	1
B27	1	3	5	0	0	0	1	1	2	50	20	30	0	0	1
B27	2	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B27	2	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B27	2	3	6	0	0	0	1	0	1	60	20	20	0	0	1
B27	3	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B27	3	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B27	3	3	6	0	0	0	1	0	1	60	20	20	0	0	1
B27	4	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B27	4	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B27	4	3	6	0	0	0	1	0	1	60	20	20	0	0	1
B27	5	1	6	0	0	0	0	0	1	0	0	0	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B27	5	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B27	5	3	6	0	0	0	1	0	1	60	20	20	0	0	1
B27	6	1	6	0	0	0	1	0	1	0	0	0	0	0	1
B27	6	2	6	0	0	0	1	0	1	0	0	0	0	0	1
B27	6	3	6	0	0	0	1	0	1	90	0	10	0	0	1
B27	7	1	6	0	0	0	0	0	0	0	0	0	0	0	1
B27	7	2	6	0	0	0	0	0	0	0	0	0	0	0	1
B27	7	3	6	0	0	0	0	0	0	100	0	0	0	0	1
B28	1	1	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	1	2	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	1	3	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	2	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B28	2	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B28	2	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B28	3	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B28	3	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B28	3	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B28	4	1	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	4	2	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	4	3	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	5	1	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	5	2	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	5	3	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	6	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B28	6	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B28	6	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B28	7	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B28	7	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B28	7	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B28	8	1	6	0	0	0	0	0	0	.	.	.	.	.	1
B28	8	2	6	0	0	0	0	0	0	.	.	.	.	.	1
B28	8	3	6	0	0	0	0	0	0	.	.	.	.	.	1
B28	9	1	6	0	0	0	0	0	0	.	.	.	.	.	1
B28	9	2	6	0	0	0	0	0	0	.	.	.	.	.	1
B28	9	3	6	0	0	0	0	0	0	.	.	.	.	.	1
B28	10	1	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	10	2	4	0	0	1	1	1	3	.	.	.	.	.	1
B28	10	3	4	0	0	1	1	1	3	.	.	.	.	.	1
B29	1	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B29	1	2	6	0	0	0	1	0	1	0	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B29	1	3	6	0	0	0	1	0	1	85	5	10	0	0	0
B29	2	1	5	0	0	1	1	1	3	0	0	0	0	0	0
B29	2	2	5	0	0	1	1	1	3	0	0	0	0	0	0
B29	2	3	5	0	0	1	1	1	3	40	10	50	0	0	0
B29	3	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B29	3	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B29	3	3	5	0	0	0	1	0	1	60	25	15	0	0	0
B29	4	1	6	0	0	1	1	0	2	0	0	0	0	0	0
B29	4	2	6	0	0	1	1	0	2	0	0	0	0	0	0
B29	4	3	6	0	0	1	1	0	2	55	15	25	5	0	0
B29	5	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B29	5	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B29	5	3	6	0	0	0	1	0	1	65	20	15	0	0	0
B29	6	1	5	0	0	1	1	0	2	0	0	0	0	0	0
B29	6	2	5	0	0	1	1	0	2	0	0	0	0	0	0
B29	6	3	5	0	0	1	1	0	2	40	25	35	0	0	0
B29	7	1	5	0	0	1	1	0	2	0	0	0	0	0	0
B29	7	2	5	0	0	1	1	0	2	0	0	0	0	0	0
B29	7	3	5	0	0	1	1	0	2	65	25	10	0	0	0
B29	8	1	5	0	0	0	1	1	2	0	0	0	0	0	0
B29	8	2	5	0	0	0	1	1	2	0	0	0	0	0	0
B29	8	3	5	0	0	0	1	1	2	40	35	25	0	0	0
B29	9	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B29	9	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B29	9	3	6	0	0	0	1	0	1	15	25	60	0	0	0
B29	10	1	6	0	0	1	1	0	2	0	0	0	0	0	0
B29	10	2	6	0	0	1	1	0	2	0	0	0	0	0	0
B29	10	3	6	0	0	1	1	0	2	85	10	15	0	0	0
B30	1	1	6	0	0	1	1	0	2	0	0	0	0	0	0
B30	1	2	6	0	0	1	1	0	2	0	0	0	0	0	0
B30	1	3	6	0	0	1	1	0	2	90	5	5	0	0	0
B30	2	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B30	2	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B30	2	3	6	0	0	0	1	0	1	95	5	0	0	0	0
B30	3	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B30	3	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B30	3	3	6	0	0	0	1	0	1	100	0	0	0	0	0
B30	4	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B30	4	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B30	4	3	6	0	0	0	1	0	1	100	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B30	5	1	0	.	.	.	.	.	.	.	.	.	.	.	0
B30	5	2	0	.	.	.	.	.	.	.	.	.	.	.	0
B30	5	3	0	.	.	.	.	.	.	.	.	.	.	.	0
B30	6	1	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	6	2	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	6	3	6	0	0	0	0	0	0	100	0	0	0	0	0
B30	7	1	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	7	2	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	7	3	6	0	0	0	0	0	0	100	0	0	0	0	0
B30	8	1	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	8	2	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	6	3	6	0	0	0	0	0	0	100	0	0	0	0	0
B30	9	1	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	9	2	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	9	3	6	0	0	0	0	0	0	100	0	0	0	0	0
B30	10	1	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	10	2	6	0	0	0	0	0	0	0	0	0	0	0	0
B30	10	3	6	0	0	0	0	0	0	100	0	0	0	0	0
B31	1	1	5	0	0	0	1	1	2	.	.	.	.	.	1
B31	1	2	5	0	0	0	1	1	2	.	.	.	.	.	1
B31	1	3	5	0	0	0	1	1	2	.	.	.	.	.	1
B31	2	1	4	0	0	1	1	1	2	.	.	.	.	.	1
B31	2	2	4	0	0	1	1	1	2	.	.	.	.	.	1
B31	2	3	4	0	0	1	1	1	2	.	.	.	.	.	1
B31	3	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	3	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	3	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	4	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	4	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	4	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	5	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	5	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	5	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	6	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	6	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	6	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	7	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	7	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	7	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	8	1	6	0	0	0	1	0	1	.	.	.	.	.	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B31	8	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	8	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B31	9	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	9	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	9	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	10	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	10	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B31	10	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	1	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	1	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	1	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	2	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B32	2	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B32	2	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B32	3	1	6	0	0	0	0	0	0	.	.	.	.	.	1
B32	3	2	6	0	0	0	0	0	0	.	.	.	.	.	1
B32	3	3	6	0	0	0	0	0	0	.	.	.	.	.	1
B32	4	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	4	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	4	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	5	1	6	0	0	0	0	0	0	.	.	.	.	.	1
B32	5	2	6	0	0	0	0	0	0	.	.	.	.	.	1
B32	5	3	6	0	0	0	0	0	0	.	.	.	.	.	1
B32	6	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	6	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	6	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	7	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	7	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	7	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	8	1	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	8	2	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	8	3	5	0	0	0	1	0	1	.	.	.	.	.	1
B32	9	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B32	9	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B32	9	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B32	10	1	6	0	0	0	1	0	1	.	.	.	.	.	1
B32	10	2	6	0	0	0	1	0	1	.	.	.	.	.	1
B32	10	3	6	0	0	0	1	0	1	.	.	.	.	.	1
B33	1	1	5	0	0	1	1	0	2	0	0	0	0	0	0
B33	1	2	5	0	0	1	1	0	2	0	0	0	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B33	1	3	5	0	0	1	1	0	2	35	55	10	0	0	0
B33	2	1	6	0	0	0	1	1	2	0	0	0	0	0	0
B33	2	2	6	0	0	0	1	1	2	0	0	0	0	0	0
B33	2	3	6	0	0	0	1	1	2	15	35	50	0	0	0
B33	3	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B33	3	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B33	3	3	6	0	0	0	1	0	1	40	30	25	0	0	0
B33	4	1	5	0	0	1	1	1	3	0	0	0	0	0	0
B33	4	2	5	0	0	1	1	1	3	0	0	0	0	0	0
B33	4	3	5	0	0	1	1	1	3	10	15	75	0	0	0
B33	5	1	6	0	0	1	1	0	2	0	0	0	0	0	0
B33	5	2	6	0	0	1	1	0	2	0	0	0	0	0	0
B33	5	3	6	0	0	1	1	0	2	55	15	30	0	0	0
B33	6	1	14	.	.	.	.	.	.	.	.	.	.	.	0
B33	6	2	14	.	.	.	.	.	.	.	.	.	.	.	0
B33	6	3	14	.	.	.	.	.	.	.	.	.	.	.	0
B33	7	1	6	0	0	0	1	0	1	0	0	0	0	0	0
B33	7	2	6	0	0	0	1	0	1	0	0	0	0	0	0
B33	7	3	6	0	0	0	1	0	1	10	20	70	0	0	0
B33	8	1	5	0	0	1	1	0	2	0	0	0	0	0	0
B33	8	2	5	0	0	1	1	0	2	0	0	0	0	0	0
B33	8	3	5	0	0	1	1	0	2	20	40	40	0	0	0
B33	9	1	6	0	0	1	1	0	2	0	0	0	0	0	0
B33	9	2	6	0	0	1	1	0	2	0	0	0	0	0	0
B33	9	3	6	0	0	1	1	0	2	75	0	25	0	0	0
B33	10	1	5	0	0	1	1	1	3	0	0	0	0	0	0
B33	10	2	5	0	0	1	1	1	3	0	0	0	0	0	0
B33	10	3	5	0	0	1	1	1	3	10	50	40	0	0	0
B34	1	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	1	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	1	3	5	0	0	0	1	0	1	50	0	50	0	0	0
B34	2	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	2	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	2	3	5	0	0	0	1	0	1	50	0	50	0	0	0
B34	3	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	3	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	3	3	5	0	0	0	1	0	1	50	0	50	0	0	0
B34	4	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	4	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	4	3	5	0	0	0	1	0	1	50	0	50	0	0	0

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
B34	5	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	5	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	5	3	5	0	0	0	1	0	1	50	0	50	0	0	0
B34	6	1	6	0	0	0	0	0	0	0	0	0	0	0	0
B34	6	2	6	0	0	0	0	0	0	0	0	0	0	0	0
B34	6	3	6	0	0	0	0	0	0	50	0	50	0	0	0
B34	7	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	7	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	7	3	5	0	0	0	1	0	1	50	0	50	0	0	0
B34	8	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	8	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	8	3	5	0	0	0	1	0	1	50	0	50	0	0	0
B34	9	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	9	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	9	3	5	0	0	0	1	0	1	50	0	50	0	0	0
B34	10	1	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	10	2	5	0	0	0	1	0	1	0	0	0	0	0	0
B34	10	3	5	0	0	0	1	0	1	50	0	50	0	0	0
C2	1	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C2	1	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C2	1	3	5	0	0	0	1	0	1	35	15	40	10	0	1
C2	2	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	2	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	2	3	6	0	0	0	1	0	1	55	15	25	5	0	1
C2	3	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	3	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	3	3	6	0	0	0	1	0	1	35	15	30	20	0	1
C2	4	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	4	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	4	3	6	0	0	0	1	0	1	35	20	35	10	0	1
C2	5	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	5	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	5	3	6	0	0	0	1	0	1	75	5	20	0	0	1
C2	6	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	6	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	6	3	6	0	0	0	1	0	1	55	10	50	0	0	1
C2	7	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	7	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C2	7	3	6	0	0	0	1	0	1	80	5	10	5	0	1
C2	8	1	5	0	0	0	1	0	1	0	0	0	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
C8	5	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C8	5	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C8	5	3	5	0	0	0	1	0	1	70	10	20	0	0	1
C8	6	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C8	6	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C8	6	3	5	0	0	0	1	0	1	55	15	15	13	0	1
C8	7	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C8	7	2	6	0	0	0	1	0	1	0	0	5	0	0	1
C8	7	3	6	0	0	0	1	0	1	25	20	40	15	0	1
C8	8	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C8	8	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C8	8	3	6	0	0	0	1	0	1	0	25	40	33	0	1
C8	9	1	5	0	0	1	1	0	2	0	0	0	0	0	1
C8	9	2	5	0	0	1	1	0	2	0	0	0	0	0	1
C8	9	3	5	0	0	1	1	0	2	55	15	20	10	0	1
C8	10	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C8	10	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C8	10	3	5	0	0	1	1	1	3	35	20	35	10	0	1
C10	1	1	6	0	0	1	1	1	3	0	0	0	0	0	1
C10	1	2	6	0	0	1	1	1	3	0	0	10	0	0	1
C10	1	3	6	0	0	1	1	1	3	70	5	25	0	0	1
C10	2	1	6	0	0	1	1	1	3	0	0	0	0	0	1
C10	2	2	6	0	0	1	1	1	3	0	0	5	0	0	1
C10	2	3	6	0	0	1	1	1	3	90	10	0	0	0	1
C10	3	1	6	0	0	1	1	1	3	0	0	0	0	0	1
C10	3	2	6	0	0	1	1	1	3	0	0	5	0	0	1
C10	3	3	6	0	0	1	1	1	3	90	5	5	0	0	1
C10	4	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C10	4	2	5	0	0	1	1	1	3	0	0	15	0	0	1
C10	4	3	5	0	0	1	1	1	3	20	10	70	0	0	1
C10	5	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C10	5	2	5	0	0	1	1	1	3	0	0	5	0	0	1
C10	5	3	5	0	0	1	1	1	3	20	55	20	5	0	1
C10	6	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C10	6	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C10	6	3	5	0	0	1	1	1	3	40	20	40	0	0	1
C10	7	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C10	7	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C10	7	3	5	0	0	1	1	1	3	15	30	55	0	0	1
C10	8	1	5	0	0	1	1	1	3	0	0	0	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
C10	6	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C10	6	3	5	0	0	1	1	1	3	60	10	25	5	0	1
C11	1	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	1	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	1	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C11	2	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	2	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	2	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C11	3	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	3	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	3	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C11	4	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	4	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	4	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C11	5	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	5	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	5	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C11	6	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	6	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	6	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C11	7	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	7	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	7	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C11	8	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	8	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	8	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C11	9	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	9	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	9	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C11	10	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	10	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C11	10	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C13	1	1	5	0	0	1	1	0	2	0	0	0	0	0	1
C13	1	2	5	0	0	1	1	0	2	0	0	15	0	0	1
C13	1	3	5	0	0	1	1	0	2	75	5	20	0	0	1
C13	2	1	5	0	0	1	1	0	2	0	0	0	0	0	1
C13	2	2	5	0	0	1	1	0	2	0	0	10	0	0	1
C13	2	3	5	0	0	1	1	0	2	60	0	40	0	0	1
C13	3	1	5	0	0	1	1	0	2	0	0	0	0	0	1
C13	3	2	5	0	0	1	1	0	2	0	0	15	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
C13	3	3	5	0	0	1	1	0	2	70	0	30	0	0	1
C13	4	1	5	0	0	1	1	0	2	0	0	0	0	0	1
C13	4	2	5	0	0	1	1	0	2	0	0	50	0	0	1
C13	4	3	5	0	0	1	1	0	2	40	5	45	0	0	1
C13	5	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C13	5	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C13	5	3	5	0	0	0	1	0	1	50	5	45	0	0	1
C13	6	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C13	6	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C13	6	3	5	0	0	0	1	0	1	50	20	30	0	0	1
C13	7	1	5	1	1	1	1	1	5	0	0	5	0	0	1
C13	7	2	5	1	1	1	1	1	5	0	0	0	0	0	1
C13	7	3	5	1	1	1	1	1	5	55	10	35	0	0	1
C13	8	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C13	8	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C13	8	3	5	0	0	0	1	0	1	0	15	75	10	0	1
C13	9	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C13	9	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C13	9	3	6	0	0	0	0	0	0	95	0	5	0	0	1
C13	10	1	6	0	0	1	1	0	2	0	0	0	0	0	1
C13	10	2	6	0	0	1	1	0	2	0	0	0	0	0	1
C13	10	3	6	0	0	1	1	0	2	85	5	5	5	0	1
C15	1	1	5	0	0	0	1	1	2	0	0	0	0	0	1
C15	1	2	5	0	0	0	1	1	2	0	0	0	0	0	1
C15	1	3	5	0	0	0	1	1	2	10	40	50	0	0	1
C15	2	1	5	0	0	0	1	1	2	0	0	0	0	0	1
C15	2	2	5	0	0	0	1	1	2	0	0	0	0	0	1
C15	2	3	5	0	0	0	1	1	2	15	30	55	0	0	1
C15	3	1	5	0	0	1	1	0	2	0	0	0	0	0	1
C15	3	2	5	0	0	1	1	0	2	0	0	0	0	0	1
C15	3	3	5	0	0	1	1	0	2	50	0	50	0	0	1
C15	4	1	5	0	0	1	1	0	2	0	0	0	0	0	1
C15	4	2	5	0	0	1	1	0	2	0	0	0	0	0	1
C13	4	3	5	0	0	1	1	0	2	25	35	45	0	0	1
C15	5	1	5	0	0	1	1	0	2	0	0	0	0	0	1
C15	5	2	5	0	0	1	1	0	2	0	0	0	0	0	1
C15	5	3	5	0	0	1	1	0	2	40	20	40	0	0	1
C15	6	1	5	0	0	0	0	0	0	0	0	0	0	0	1
C15	6	2	5	0	0	0	0	0	0	0	0	0	0	0	1
C15	6	3	5	0	0	0	0	0	0	0	70	30	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
C15	7	1	5	0	0	0	0	0	0	0	0	0	0	0	1
C15	7	2	5	0	0	0	0	0	0	0	0	0	0	0	1
C15	7	3	5	0	0	0	0	0	0	25	35	40	0	0	1
C15	8	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C15	8	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C15	8	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C15	9	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C15	9	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C15	9	3	6	0	0	0	1	0	1	85	5	10	0	0	1
C15	10	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C15	10	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C15	10	3	6	0	0	0	1	0	1	50	30	20	0	0	1
C16	1	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	1	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	1	3	6	0	0	0	1	0	1	95	0	5	0	0	1
C16	2	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C16	2	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C16	2	3	5	0	0	0	1	0	1	65	15	20	0	0	1
C16	3	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C16	3	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C16	3	3	5	0	0	0	1	0	1	70	10	20	0	0	1
C16	4	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C16	4	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C16	4	3	5	0	0	0	1	0	1	45	5	55	0	0	1
C16	5	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	5	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	5	3	6	0	0	0	1	0	1	90	5	10	0	0	1
C16	6	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	6	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	6	3	6	0	0	0	1	0	1	35	25	40	0	0	1
C16	7	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C16	7	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C16	7	3	5	0	0	0	1	0	1	30	25	35	10	0	1
C16	8	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	8	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	8	3	6	0	0	0	1	0	1	20	5	20	55	0	1
C16	9	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	9	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	9	3	6	0	0	0	1	0	1	80	0	20	0	0	1
C16	10	1	6	0	0	0	1	0	1	0	0	0	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence ~ Previous Afforestation
C16	10	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C16	10	3	6	0	0	0	1	0	1	95	0	5	0	0	1
C17	1	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	1	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	1	3	5	0	0	1	1	1	3	30	20	50	0	0	1
C17	2	1	5	0	0	1	1	0	2	0	0	0	0	0	1
C17	2	2	5	0	0	1	1	0	2	0	0	0	0	0	1
C17	2	3	5	0	0	1	1	0	2	15	20	65	0	0	1
C17	3	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	3	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	3	3	5	0	0	1	1	1	3	35	20	30	15	0	1
C17	4	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	4	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	4	3	5	0	0	1	1	1	3	5	5	90	0	0	1
C17	5	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	5	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	5	3	5	0	0	1	1	1	3	0	5	95	0	0	1
C17	6	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	6	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C17	6	3	5	0	0	1	1	1	3	35	10	55	0	0	1
C17	7	1	5	0	0	0	1	1	2	0	0	0	0	0	1
C17	7	2	5	0	0	0	1	1	2	0	0	0	0	0	1
C17	7	3	5	0	0	0	1	1	2	15	15	70	0	0	1
C17	8	1	5	0	0	0	1	1	2	0	0	0	0	0	1
C17	8	2	5	0	0	0	1	1	2	0	0	5	0	0	1
C17	8	3	5	0	0	0	1	1	2	35	15	50	0	0	1
C17	9	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C17	9	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C17	9	3	6	0	0	0	0	0	0	95	0	5	5	0	1
C17	10	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C17	10	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C17	10	3	5	0	0	0	1	0	1	60	5	35	5	0	1
C18	1	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C18	1	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C18	1	3	6	0	0	0	1	0	1	75	10	15	0	0	1
C18	2	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C18	2	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C18	2	3	5	0	0	0	1	0	1	30	30	40	0	0	1
C18	3	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C18	3	2	5	0	0	1	1	1	3	0	0	0	0	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
C18	3	3	5	0	0	1	1	1	3	10	30	60	0	0	1
C18	4	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C18	4	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C18	4	3	5	0	0	1	1	1	5	5	30	60	5	0	1
C18	5	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C18	5	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C18	5	3	6	0	0	0	1	0	1	45	10	45	0	0	1
C18	6	1	5	0	0	1	1	1	3	0	0	0	0	0	1
C18	6	2	5	0	0	1	1	1	3	0	0	0	0	0	1
C18	6	3	5	0	0	1	1	1	3	5	30	55	10	0	1
C18	7	1	4	0	0	1	1	1	3	0	0	0	0	0	1
C18	7	2	4	0	0	1	1	1	3	0	0	40	0	0	1
C18	7	3	4	0	0	1	1	1	3	15	15	70	0	0	1
C18	8	1	5	0	0	0	1	1	2	0	0	0	0	0	1
C18	8	2	5	0	0	0	1	1	2	0	0	35	0	0	1
C18	8	3	5	0	0	0	1	1	2	30	30	40	0	0	1
C18	9	1	4	0	0	1	1	1	3	0	0	0	0	0	1
C18	9	2	4	0	0	1	1	1	3	0	0	40	0	0	1
C18	9	3	4	0	0	1	1	1	3	0	10	83	5	0	1
C18	10	1	5	0	0	0	1	0	1	0	0	0	0	0	1
C18	10	2	5	0	0	0	1	0	1	0	0	0	0	0	1
C18	10	3	5	0	0	0	1	0	1	33	15	50	0	0	1
C19	1	1	4	0	0	1	1	1	3	0	0	0	0	0	1
C19	1	2	4	0	0	1	1	1	3	0	0	10	0	0	1
C19	1	3	4	0	0	1	1	1	3	93	0	5	0	0	1
C19	2	1	4	0	0	1	1	1	3	0	0	0	0	0	1
C19	2	2	4	0	0	1	1	1	3	0	0	15	0	0	1
C19	2	3	4	0	0	1	1	1	3	75	15	10	0	0	1
C19	3	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C19	3	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C19	3	3	6	0	0	0	0	0	0	95	5	0	0	0	1
C19	4	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C19	4	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C19	4	3	6	0	0	0	0	0	0	80	10	10	0	0	1
C19	5	1	6	0	0	1	1	1	3	0	0	0	0	0	1
C19	5	2	6	0	0	1	1	1	3	0	0	5	0	0	1
C19	5	3	6	0	0	1	1	1	3	90	5	5	0	0	1
C19	6	1	4	0	0	1	1	1	3	0	0	0	0	0	1
C19	6	2	4	0	0	1	1	1	3	0	0	10	0	0	1
C19	6	3	4	0	0	1	1	1	3	10	25	60	5	0	1

Site	Line Intercept No.	Layer No.	Cover Type	Tree Canopy	Tree Bole	Shrub Midstory	Under-story	Terrestrial Subsurface	No. of Layers	Bare Ground	Litter	Vegetation	Fallen Timber	Rock	Evidence – Previous Afforestation
C19	7	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C19	7	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C19	7	3	6	0	0	0	0	0	0	90	0	10	0	0	1
C19	8	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C19	8	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C19	8	3	6	0	0	0	1	0	1	85	10	5	0	0	1
C19	9	1	6	0	0	0	0	0	0	0	0	0	0	0	1
C19	9	2	6	0	0	0	0	0	0	0	0	0	0	0	1
C19	9	3	6	0	0	0	0	0	0	100	0	0	0	0	1
C19	10	1	6	0	0	0	1	0	1	0	0	0	0	0	1
C19	10	2	6	0	0	0	1	0	1	0	0	0	0	0	1
C19	10	3	6	0	0	0	1	0	1	93	15	0	0	0	1

ATTACHMENT B

Dominant Vegetation Species in Impact Area Grasslands During 1994 Sampling

KEY

Line intercept no.	1 to 10 sample site
BBWG	Bluebunch wheatgrass
BBWG/RF	Bluebunch wheatgrass and rough fescue
GBWR	Great Basin wild rye
GBWR/RRB	Great Basin wild rye and rubber rabbit brush
IF/BBWG	Idaho fescue and bluebunch wheatgrass
IF/GBWR	Idaho fescue and Great Basin wild rye
RF/IF	Rough fescue and Idaho fescue
RT	Redtop
RT/BBWG	Redtop and bluebunch wheatgrass
RT/GBWR	Redtop and Great Basin wild rye
SKN	Spotted knapweed
SKN/RT	Spotted knapweed and redtop
THIS	Thistle
THIS/GBWR	Thistle and Great Basin wild rye
WT	Whitetop

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
A1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
A7	10	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
A9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
A11	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
A11	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
A12	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
A13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
A16	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
A20	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
A20	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B1	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B1	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B4	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B4	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B4	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B4	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B4	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B6	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B6	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B6	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B6	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B6	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B6	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B10	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
B10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B10	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B10	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B10	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B10	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B10	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B12	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B14	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B14	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B14	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B14	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B14	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B14	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B14	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B14	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B14	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B17	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B17	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B17	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B17	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B17	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B17	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B17	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B17	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B17	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B17	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B19	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
B19	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B19	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
B19	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
B19	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B19	6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
B19	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B19	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
B19	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B19	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B21	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B21	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B21	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B21	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B21	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B21	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B21	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B21	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B21	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
B22	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
B22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B22	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B22	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B22	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B22	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B22	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B22	8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
B22	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B22	10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
B23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B23	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B23	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B23	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B23	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B23	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B23	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B23	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
B23	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B23	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B24	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B24	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B24	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B24	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B24	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B24	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B24	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B24	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B24	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B24	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B26	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B26	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B26	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B26	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B26	6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B26	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B26	8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B26	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B26	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B27	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B27	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B27	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B27	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B27	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B27	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B27	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B28	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
B29	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
B29	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B29	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B29	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B29	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B29	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B29	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B29	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B29	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B30	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B30	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B30	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B30	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B30	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B30	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B30	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B30	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B30	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B30	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B31	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B32	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
B32	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B32	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B32	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
B32	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B32	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B32	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B32	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B32	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B32	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B33	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
B33	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B33	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B33	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
B33	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B33	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B33	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B33	8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
B33	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B33	10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
B34	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B34	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B34	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B34	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B34	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B34	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B34	7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B34	8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B34	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B34	10	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C2	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C6	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C8	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C8	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C8	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C13	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C13	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C13	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C13	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C13	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C13	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C13	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C13	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C15	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C15	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C15	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C15	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C15	6	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C15	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C15	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C16	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C16	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C16	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C17	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C17	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C17	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C17	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C17	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C17	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C17	8	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
C17	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C18	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C18	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C18	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C18	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C18	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C18	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C20	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C21	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C22	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C22	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C23	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C23	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C23	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C23	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C24	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C24	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C25	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C25	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C26	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C26	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C26	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C26	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C26	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C26	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C26	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C26	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C26	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C26	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C26	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C27	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C27	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C27	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C27	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C27	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C27	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C27	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C27	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C27	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C27	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C27	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C27	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C27	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C27	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C27	8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C27	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C27	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C27	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C27	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C27	8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C27	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C27	8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C27	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C27	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C27	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C27	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C27	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C27	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C27	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C27	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Site	Line Intercept No.	SKN	THIS	RT	IF/BBWG	RT/BBWG	IF/GBWR	GBWR	RT/GBWR	WT	BBWG	THIS/GBWR	BBWG/RF	RF/IF	GBWR/RRB	SKN/RT
C28	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C28	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C29	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	9	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C29	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	9	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C29	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C29	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C29	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C29	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C29	9	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

APPENDIX E

Assessment of Injury to Semi-Aquatic Mammals

FINAL REPORT

Exposure to and injury from environmental metal contamination on semi-aquatic mammals in the upper Clark Fork River, Montana.

Research Report on Injury Determination

Wildlife Protocols #4 and #5

Assessment Plan, Part II

Clark Fork River Basin NPL Sites, Montana

Submitted by:

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INTRODUCTION

Over 100 years of mining has left the Clark Fork River basin in Montana with serious environmental contamination problems. Three areas of the Clark Fork drainage impacted by mining, from the city of Butte at the river's headwaters to the Milltown Reservoir near Missoula, have been placed on EPA's National Priorities List (NPL): (1) the mining region itself in Butte with its associated workings, contaminated soils, tailings, and ground water, as well as the entire 145 miles of river from Butte to the Milltown Reservoir; (2) The Anaconda smelter complex including the Old Works and Washoe smelter grounds, Opportunity and Anaconda Ponds and surrounding areas; and (3) the Milltown Reservoir (MDHES and USEPA 1990).

The primary mining-related contaminants of concern found elevated in the riparian areas of the Clark Fork drainage include copper (Cu), zinc (Zn), lead (Pb), cadmium (Cd), and arsenic (As) (USGS 1989). These are found primarily in stream-side tailings, pond sludges and river sediments, and in the surface water and adjacent ground water of Silver Bow Creek and the Clark Fork (MDHES and USEPA 1991, USEPA and MDHES 1991). River bed sediments of Silver Bow Creek and the upper Clark Fork consist, to a large extent, of old mill tailings. These sediments contain metal concentrations 10 to 100 times above background levels for a distance of 20 km downstream from Warm Springs Ponds (Andrews 1987).

Of the four metals and one metalloid found to be elevated in

Silver Bow Creek and the Clark Fork River, three (Pb, Cd, As) are of particular concern because of proven toxicity to mammals. Elevated levels of Cu and Zn pose less severe environmental problems for mammals because of homeostatic mechanisms regulating these metals. Several semi-aquatic mammalian species inhabiting the upper Clark Fork drainage are potentially at risk from elevated levels of Pb, Cd, and As in their diet of aquatic food items. These include river otter (*Lutra canadensis*) and mink (*Mustela vison*), which rely heavily or entirely on a diet of fish and aquatic macroinvertebrates (Melquist and Dronkert 1987, Eagle and Whitman 1987), raccoons (*Procyon lotor*), which can feed extensively on fish and aquatic macroinvertebrates (Sanderson 1987), and muskrats (*Ondatra zibethicus*), which feed on submerged aquatic vegetation (Boutin and Birkenholz 1987).

Tissues from river otter, mink, raccoon, and muskrat collected in areas with anthropogenic inputs of metals have been shown to contain elevated concentrations of lead (Blus and Henny 1990, Valentine et al. 1988, Wren et al. 1988, Niethammer et al. 1985, Erickson and Lindzey 1983), cadmium (Wren et al. 1988, Blus et al. 1987, Niethammer et al. 1985, Ogle et al. 1985, Everett and Anthony 1976), zinc (Everett and Anthony 1976), copper (Wren et al. 1988, Everett and Anthony 1976), and mercury (Wren et al. 1986, Kucera 1982, Cumbie and Jenkins 1985, Clark et al. 1981) compared to animals from uncontaminated areas. Adverse effects on wildlife, including death (Wren 1985, Diters and Nielsen 1978, Benson et al. 1976, Wobeser 1976) and reduced local population

numbers (Blus and Henny 1990, Eisler 1988, Eisler 1985) have been attributed to metal contamination from anthropogenic sources. Otter and mink are presently considered by U.S., Canadian, and European experts as the two mammalian species most sensitive to aquatic pollutants in streams and lakes because of their position at the top of the aquatic food chain, and because of demonstrated sensitivity of these two species to contaminants in their aquatic food base (Addison et al. 1991).

Based on recent trapping records, river otter are believed to be absent from the upper Clark Fork River, and state wildlife authorities suspect mining contaminants as a probable cause (Howard Hash, Furbearer Biologist, Montana Department of Fish, Wildlife and Parks, pers. comm.). One aspect of this study on semi-aquatic mammals will investigate whether otter are in fact absent from the upper Clark Fork River and whether this absence can be explained by the direct or indirect effects of metal contamination in the environment. Since there appear to be no otter on the upper Clark Fork River, determining the potential effects of metal contamination on this species required, in part, use of a suitable surrogate species. Mink were selected as the surrogate species since they occupy a similar piscivorous, upper trophic position as otter, and are still present on the upper Clark Fork River.

The first objective of this study was to determine the extent of metal accumulation through the upper Clark Fork River aquatic food chain and was accomplished through four tasks:

<u>Task 1</u>. Identify the principal aquatic food items of mink inhabiting the upper Clark Fork and reference sites.

<u>Task 2</u>. Determine whole body metal residue concentrations of principal aquatic food items of mink collected from the Clark Fork and reference sites.

<u>Task 3</u>. Determine Clark Fork mink metal concentrations in tissues known to sustain injury by elevated levels. These will be compared to background tissue concentrations in mink collected from reference sites.

<u>Task 4</u>. Compare tissue metal concentrations of Clark Fork mink with literature values associated with injury.

The second objective involved identifying actual or potential adverse effects from mining and environmental metal contamination on individuals and/or populations of piscivorous mammals currently inhabiting, or expected to inhabit the Clark Fork River. This was accomplished through the following five tasks:

<u>Task 5</u>. Determine the relative abundance of semi-aquatic mammals along the upper Clark Fork and reference sites.

<u>Task 6</u>. Compare the relative quality of streamside habitat for semi-aquatic mammals along the upper Clark Fork and reference sites. This would examine whether potential differences in animal abundance were related to differences in streamside habitat quality, to mining related metal contamination, or to other human disturbances.

Task 7. Monitor for morphological and histological injuries associated with metal toxicity in mink collected from the upper Clark Fork and reference sites.

Task 8. Determine the extent of trapping, numbers of humans and livestock, irrigation demands, and average distance to the nearest highway along the upper Clark Fork and reference sites.

Task 9. Determine whether Clark Fork River fish tissue metal concentrations are above the safe limit for consumption by piscivorous, semi-aquatic mammals .

If deleterious metal-related effects can be demonstrated in the piscivorous mammalian species inhabiting the upper Clark Fork River, either within individuals or to resources critical to the population, it would be compelling evidence that environmental metal contamination continues to negatively affect populations of piscivorous mammals, and is responsible for any absence of, or reductions to these populations.

METHODS

Procedures were followed in accordance with Section 2.4.5.3 of the State of Montana, Natural Resource Damage Program Assessment Plan, Part II, except where noted.

Injury to Birds

(Note: The migratory nature of piscivorous birds seasonally inhabiting the upper Clark Fork and reference sites would make accurate determination of exposure and injury specifically related to hazardous substances from the upper Clark Fork difficult. It was therefore decided not to pursue such determinations.)

Injury to Semi-Aquatic Mammals (Furbearers)

(Note: Since a main focus of this study involves an investigation of river otter absence along the upper Clark Fork through the study of mink as a surrogate species, the identification of food items (Task 1), metal residue determination in food items (Task 2), and metal residue determinations, comparisons, and injury in mammalian tissues (Tasks 3, 4, and 7) were limited to mink alone. Determination of relative abundance (Task 5), habitat quality (Task 6), human disturbance (Task 8), and metal criteria (Task 9) addressed mink, otter and other semi-aquatic mammals on the Clark Fork and reference sites.)

Mink Collection

Mink were collected during the 1991 - 1992 trapping season from several stretches of the Clark Fork River including from Silver Bow Creek just above Warm Springs Ponds to Racetrack Creek, from Deer Lodge to Garrison, and from near Drummond to Clinton. Mink were also collected from several rivers and creeks with no known metal contamination sources including the upper Big Hole River from Toomey Creek to Fishtrap Creek, upper Rock Creek near the Kaiser Lake turnoff, the lower six miles of Rock Creek near its confluence with the Clark Fork, and upper Mill Creek at Mill Creek Falls (Figure 1). Animals were trapped under license by the investigators and by cooperating trappers in standard leg-hold traps employing drowning sets. Upon capture or upon receipt from trappers each carcass was tagged with a unique I.D. number, measured in length, weighed, and sexed. The approximate trap location for each animal was determined on 1:24,000 USGS topographic maps. Animals caught more than twenty-four hours prior to collection, or which were already frozen upon receipt, were archived frozen for later processing. Animals collected under twenty-four hours from the time of trapping were dissected immediately for metal residue and histologic samples.

Identification of Principal Food Items of Mink (Task 1)

Prey items of mink were identified from stomach and lower intestinal contents of mink carcasses collected during the 1991-92 trapping season. Food items were identified to the lowest

possible taxonomic unit using a dissecting microscope. Fish species were identified by comparison of the fish scales present in the sample to scales from species collected from the Clark Fork and reference sites. Other prey items such as mammals, herps, or birds were identified (at least to class) by bone, hair, and feather remains. Crayfish and other macroinvertebrates were identified by the presence of exoskeleton remains. The importance of each food item in the diet is presented as the frequency of occurrence in all samples.

Aquatic Prey Item Residue Analysis (Task 2)

Mountain whitefish (Prosopium williamsoni), largescale sucker (Catostomus macrocheilus), longnose sucker (Catostomus catostomus), and brown trout (Salmo trutta) were collected in August of 1991 and May of 1992 from several sites along the Clark Fork River, one site on the Big Hole River, and one site along Rock Creek using electro-shocking. Fish collection on the Clark Fork included sites just below Warm Springs Ponds and just above the Turah Bridge public fishing access. Reference site fish were collected from the Big Hole near the Glen public fishing access and from Rock Creek at the Sawmill fishing access (Figure 2). All fish were immediately placed on ice and stored frozen until further processing was possible. From each site, each species of fish was sorted by size and up to five fish from one comparable size class were then randomly selected for whole body residue analysis. The fish samples were homogenized in a stainless steel

Waring blender, which had been prewashed with hydro-pure water, and digested in nitric acid at 90°C. Digestates were analyzed for Pb, and Cd by graphite furnace atomic absorption spectrophotometry, for Cu and Zn using flame atomic absorption spectrophotometry, and for As by flame atomic absorption spectrophotometry coupled to an As hydride generator. A more complete description of the sample preparation and analysis procedure is presented in UW SOP P.35 and UW SOP P.36.

Mink Tissue Residue Analysis (Task 3)

Liver, kidneys, and brain were dissected out of each carcass, a subsample was taken for histological examination, and the remainder of each tissue was placed into acid washed vials (Wheaton Brand) and stored frozen for later determination of metal residue concentrations. Sample preparation included homogenization in a stainless steel Sorvall mixer and digestion in nitric acid at 90°C. Digestates were analyzed for Pb, Cd, Cu, Zn and As using the same procedures specified above for fish, as described in UW SOP P.35 and UW SOP P.36.

Literature Tissue Metal Concentration Comparison (Task 4)

An extensive literature search was conducted on tissue metal concentrations in mink collected from both industrialized and non-industrialized environments. These values were then compared to metal concentrations of mink collected from the Clark Fork and references sites.

Sign Survey/Riparian Habitat Site Selection (Tasks 5 and 6)

The Clark Fork River, from Warm Springs Ponds to the Milltown Reservoir (i.e., not including Silver Bow Creek), was divided into six sections of approximately 45 kilometers in length. Each section was further divided into walkable lengths approximately 15 kilometers long. One length within each section was then randomly selected for the sign survey/habitat evaluation. A reference site of similar length was paired to each Clark Fork site based on similarities in dominant riparian habitat, river basin morphology, stream discharge, dominant land use practice, and elevation (see UW SOP P.34).

Using the above criteria, one site on the Big Hole River was paired to each of the selected Clark Fork sites (Figure 3). The Big Hole has similar stream discharge compared to the Clark Fork. Valley topography and riparian zone vegetation are also very similar between the Clark Fork and the Big Hole with both beginning as an open treeless valley vegetated by willows, changing into a more narrow valley dominated by a coniferous/deciduous mixed overstory with a well developed shrub understory. Land use practices are also similar in the two valleys with cattle ranching and hay production the two most common forms of agriculture. Selected Big Hole sites are similar although slightly higher in elevation than their paired Clark Fork sites.

In the selection process, eight additional streams were considered for possible paired reference sites including the

Bitterroot River, the Blackfoot River, Rock Creek, the Little Blackfoot River, Wise River, the Jefferson River, the Ruby River and the Beaverhead River. The Bitterroot River was eliminated from consideration because of differences in stream habitat type, river basin morphology, and total stream discharge. Several nearby streams (Rock Creek, the Little Blackfoot, and the Wise River) were eliminated primarily because their discharge is much less than that of the Clark Fork, as well as because of differences in river basin topography compared to possible Clark Fork sites. The Jefferson River was not considered suitable because of its much greater stream discharge compared to the Clark Fork, and because of differences in riparian habitat. Both the Ruby River and the Beaverhead River were also eliminated because of dissimilarities in riparian habitat compared to the Clark Fork.

Sign Survey for Semi-Aquatic Mammals (Task 5)

(Note: Scent stations were not employed in determining relative species abundance.)

Animal sign surveys have been used to determine relative abundance for several semi-aquatic mammalian species including otter (Mason and Macdonald 1987, Bradley 1986, Zackheim 1982) and mink (Foley et al. 1991). While it is not possible to infer a population size from such an index, it does provide valuable information for relative comparisons of animal populations between sites (Foley et al. 1991). It is important to run the

surveys between paired sites at approximately the same time of year to avoid confounding factors that may seasonally alter animal activity such as migration, reproduction, or changes in food availability. During our surveys, temporal effects on species sign were minimal.

In addition to running sign surveys for semi-aquatic mammals at the same time of the year, it is also important to run the surveys at approximately the same stream flow conditions since water levels will influence the presence/absence of sign. Examining paired experimental and reference sites under dissimilar stream flow conditions would therefore bias the results in favor of the site with the lower water levels.

Paired Clark Fork River and reference sites selected for the furbearer sign survey were those surveyed for habitat and cover (Figure 3). The streams considered as possible reference sites and the criteria behind site selection is found in UW SOP P.33, and summarized above under 'Sign Survey/Riparian Habitat Site Selection'.

An intensive search approach within each survey site was used to identify sign of furbearers (see UW SOP P.33). The types of sign recorded included tracks, scat/latrines, runways, fresh chewing activity, scent mounds, bank dens, and sightings. Data were then converted for each furbearer species into a relative abundance index (number of sign encountered per kilometer) for each of the sites walked. Surveys were conducted twice during 1992, once in late May - early June, and again in mid October -

early November.

During the spring 1992 surveys, stream discharge on the Clark Fork dropped continuously over the 25 days prior to the survey as recorded by the USGS gauging station at Turah Bridge (USGS 1992). The effect of these dropping water levels was the presence of a large number of extensive, exposed mud bars over much of each site surveyed. In contrast, stream discharge increased on the Big Hole over the five days prior to the survey as recorded by the gauging station near Melrose (USGS 1992). This increase in stream discharge was evidenced by submerged bank grass and the absence of any mud or sand bars. For this reason, survey data from spring 1992 was deemed invalid and not used in the analysis of sign survey data.

Riparian Zone Habitat Analysis (Task 6)

(Note: Riparian habitat was not evaluated by the Habitat Evaluation Procedure (HEP) or by the similar Habitat Suitability Index (HSI) models for furbearers. Models currently under development by the U.S. Fish and Wildlife Service were deemed inadequate as a means of evaluating the riparian zone for the semi-aquatic mammals because models are not available for all species under consideration (Arthur W. Allen, U.S. Fish and Wildlife Service, Fort Collins, CO, Pers. Comm.).)

A riparian habitat survey (UW SOP P.34) was conducted during the fall of 1992 to determine whether differences exist between the Clark Fork and reference sites in habitat characteristics

immediately adjacent to the water's edge. This habitat is of prime importance to piscivorous mammals.

Six Clark Fork River sites of approximately 15 kilometers in length were each paired to a reference site of similar length on the Big Hole River. As noted above, the sites for the habitat survey were the same as those surveyed for furbearer sign. The rationale for site selection are presented above and the six selected Clark Fork and reference sites are shown in Figure 3.

In conducting the habitat survey, each Clark Fork or reference site was sampled for habitat characteristics at sampling points determined by walking at a constant pace for five minutes from the last sampling point. At each sampling point the habitat was classified on each river bank, encompassing an area 30 m upstream, 30 m downstream, and 20 m inland from each bank. Descriptions of habitat classification categories are found in Appendix 1.

Each sampling point was also evaluated for its bank cover potential for otter. The proximity of cover immediately adjacent to the water's edge is considered important to otter (Melquist and Dronkert 1987) as is the bank height which otters are required to climb in order to reach resting areas (Tom Beck, Colorado Division of Wildlife, pers. comm.). Therefore, bank height, distance to nearest cover, and cover type were measured to determine if the habitat immediately adjacent to the water's edge is significantly altered on the Clark Fork River compared to the bankside habitat of the Big Hole River, which contains otter

(UW SOP P.34). Appendix 2 contains a list of cover types encountered.

Mink Health/Age Assessment (Task 7)

(Note: The mink health assessment/age determination was added to the original assessment plan).

A necropsy was performed on each mink carcass collected during the 1991/1992 trapping season. The necropsy procedure used in the wildlife health assessment (UW SOP P.32) was adapted from a standard mammalian necropsy procedure employed by State Pathologist Dr. Elizabeth Williams, at the Wyoming State Veterinary Laboratory in Laramie, Wyoming. A necropsy record (Appendix 3) completed for each carcass, indicates which tissues were examined, and which tissues were sampled for histological and metal residue analysis, along with their appropriate sample vial numbers.

A histological examination for microscopic tissue abnormalities associated with metal injury as well as non-metal related pathologies (e.g., bacterial, viral, and parasitic) was conducted on all major tissue types including tongue, lung, heart, liver, gall bladder, kidney, spleen, pancreas, stomach, mesenteric lymph node, brain, testes/ovary, urinary bladder, and skeletal muscle. Histology samples were sectioned and evaluated by the State Veterinary Laboratory and Dr. Williams.

Mink were placed into adult or juvenile age classes by the use of tooth cementum annuli. Canines from carcasses were

decalcified, sectioned, stained, and read at the Wyoming Game and Fish analytical research laboratory in Laramie, Wyoming. Mink with canines displaying no cementum annuli were considered young of the year (juveniles). Mink with canines having one or more annuli were considered adults.

Level of Human Disturbance (Task 8)

Review Of Recent Trapping Records

(Note: A review of recent trapping records was added to the original assessment plan).

Otter and beaver are considered closely associated species, with beaver activities greatly enhancing riparian habitat for otters (Melquist and Dronkert 1987). Because of this ability to enhance the riparian zone for otter, the presence of beaver is one of the best predictors of otter presence in areas where both species are likely to be found (Dubuc et al. 1990). Since otter and beaver share the same habitat, most otters trapped in Montana are captured incidental to beaver trapping activities (Howard Hash, MDFWP furbearer biologist pers. comm.). It is therefore reasonable to conclude that if two areas of similar size have similar harvest levels of beaver, they would also be expected to have similar levels of incidental otter captures, if otter populations are approximately the same size in the two areas. With this in mind, otter and beaver trapping records from Montana Department of Fish, Wildlife, and Parks (MDFWP) files were reviewed. Detailed records have been kept on otter captures

since 1980. From that time on, the carcass of any otter trapped within the state were required to be registered with MDFWP. Records on beaver trapping come from responses to a yearly state-wide questionnaire, which has been in use since 1985. Beaver harvest data are reported by hunting district, while otter harvest data include a written description of the specific trap location in addition to the hunting district where the animal was captured.

Otter and beaver trapping data were compared between two areas of southwest Montana of similar size (MDFWP administrative regions two (west central Montana encompassing the Clark Fork, Bitterroot, and Blackfoot River drainages) and three (south western Montana encompassing the Big Hole, Beaverhead, Jefferson, Madison, and Gallatin River drainages). Trapping records of beaver were used in conjunction with USGS maps to determine the number of beaver captured per unit area from each of the two MDFWP regions, for each of the five years for which beaver data have been collected and compiled (1985 - 1989). This was accomplished by dividing the yearly catch total for each region by the region's area determined by planimetry from a 1:500,000 USGS map of western Montana. The indices were then compared between regions.

The number of otter trapped per river mile was also compared between the Clark Fork, Big Hole, and Bitterroot River drainages over a nine year period. For each year, the number of otter trapped on the main stem and along tributaries of each of these

three rivers was tallied. Each river's yearly total was then divided by its total length (in miles) providing the number of otter caught per mile. The Clark Fork was evaluated from Warm Springs Ponds to the Milltown reservoir, the Big Hole River from Jackson to its confluence with the Jefferson River, and the Bitterroot River from its headwaters in the Bitterroot National Forest to its confluence with the Clark Fork (Figure 4).

Human Populations, Livestock Numbers, and Irrigation Demands

The human populations living along the Clark Fork River and reference sites were estimated from 1990 US census figures, and the number of livestock within each drainage was determined by grazing figures from county extension agents. Irrigation demands were determined from USGS stream discharge records. Average distance to nearest highway was measured off of 1:24,000 USGS topographic maps.

Comparison of Tissue Residue Criteria for Consumption of Fish by Mink and Otter with Metal Concentrations in Clark Fork and Reference Site Fish (Task 9)

(Note: The evaluation of tissue residue criteria for dietary consumption of fish by mink and otter was added to the original assessment plan).

Of the several models recently developed to estimate the maximum safe dietary exposure, or "Tissue Residue Criterion", of a toxicant by piscivorous mammals, the model employed by the New York State Department of Environmental Conservation (Newell et

al. 1987) was chosen for use in this evaluation, because it has been widely accepted by the scientific community, and because it serves as the basis for other similar models such as the Canadian Tissue Residue Guidelines (USEPA 1992).

Using this model we evaluated the dietary exposure to Cd and Pb of mink and otter consuming fish from the Clark Fork and reference sites, because of the availability of suitable laboratory toxicity studies, and because of the thoroughly demonstrated lethal and sub-lethal effects of these metals in mammals (Eisler 1988, 1985). The two criteria values calculated for each species were based on a subchronic Cd LOAEL (Lowest Observed Adverse Effect Level) reported for birth defects in rats (Ferm and Layton 1981), and a Pb LOAEL reported for behavioral effects in monkeys (Rice 1985).

The total dietary intake of Pb by mink and otter was then estimated using whole body tissue residue concentrations from fish collected during this study, and by using average body weights, species' feeding rates, and dietary trophic level composition specified by USEPA (1993) for mink and otter. This model only evaluates dietary exposure to one metal at a time, and therefore does not address possible additive or synergistic toxicological effects between Clark Fork metals such as Pb and Cd.

The model generates a criterion value or Tissue Residue Criterion (TRC) in terms of the maximum acceptable exposure concentration for each metal (in ug of metal/kg diet) of a

contaminant (Pb or Cd) in the diet, and is defined by the following equation:

$$TRC = \frac{NOAEL \times BW}{FR}$$

where,

$$NOAEL = \frac{LOAEL}{UF_B \times UF_S \times UF_C}$$

and where,

TRC = Tissue Residue Criterion

The maximum acceptable exposure concentration in the diet that is expected to produce no adverse effects, expressed in ug metal/kg diet.

NOAEL = No Observed Adverse Effect Level

Expressed in terms of ug of Cd or Pb consumed per kilogram body weight per day (ug metal/kg/d). A NOAEL must be determined from a suitable chronic or subchronic laboratory toxicity test using a mammalian wildlife species or using a representative mammalian species (e.g., similar body weight and life span). If a suitable NOAEL is not available the NOAEL can be estimated from a LOAEL (defined below) determined in a properly conducted chronic or subchronic laboratory study.

BW = Species' Body Weight

Expressed in kilograms. Mink and otter body weights (1 and 8 kg, respectively) used in application of the model were values employed by Newell et al. (1987) and adopted by EPA in the recently developed water quality criteria model for protection of piscivorous wildlife species (USEPA 1993).

FR = Species' Feeding Rate

Expressed in kilograms per day. Mink and otter feeding rates (0.15 and 0.9 kg/d, respectively) used in our application of the model were values employed by Newell et al. (1987) and adopted by EPA in the recently developed water quality criteria model for protection of piscivorous wildlife species (USEPA 1993).

LOAEL = Lowest Observed Adverse Effect Level

A LOAEL must be determined in a properly conducted chronic or subchronic laboratory study, with a mammalian wildlife species or a representative mammalian species (e.g., similar body weight and life span). As noted above, a NOAEL can then be estimated by dividing the LOAEL by appropriate uncertainty factors (below).

UF_E = An uncertainty factor used to estimate a NOAEL when only a LOAEL is available. If a suitable NOAEL is available the uncertainty factor = 1; if only a NOAEL is available the uncertainty factor = 10.

UF_S = An interspecies uncertainty factor used to estimate a NOAEL for a wildlife species when toxicity date are not available for the same or a comparable species. An uncertainty factor of 1 or 10 is normally used.

UF_C = An uncertainty factor used to estimate a chronic NOAEL from subchronic data, when the subchronic test was substantially shorter than the full life cycle of the test species. An uncertainty factor of 1 to 10 is normally used.

Statistical Procedures

Paired site data including major habitat type, distance to nearest cover, nearest cover type, bank height, as well as furbearer sign and recent trapping record data, were statistically compared using a two tailed randomization, while mink liver, kidney, and brain tissue metal residues, and the whole body fish metal residue data were compared using a one tailed randomization (Manly 1991). A significance level of α = 0.05 was used for all statistical tests.

RESULTS

Mink Collection

Twenty-seven mink were collected during the 1991-1992 trapping season, sixteen on the Clark Fork and eleven from reference sites. Descriptions of trap location, age, and sex for each mink are presented in Appendix 4. Eight of the twenty-seven were female, seven of which came from the Clark Fork near Clinton and Rock Creek near its confluence with the Clark Fork. The remaining female was trapped on Silver Bow Creek, approximately 100 meters upstream from I-90. Nineteen male mink were collected near Warm Springs, Deer Lodge, and on the reference sites.

Identification of Principal Food Items of Mink (Task 1)

Fish occurred with the greatest frequency in both intestine (61.5 percent; 84 percent of intestines with food present) and stomach samples (11.5 percent; 60 percent of stomachs with food present)(Table 1). Fish species identified in samples included mountain whitefish, sucker (unknown species), and trout (probably brown trout). Aquatic invertebrates were found with relatively high frequency in intestinal samples (26.9 percent), but were minor in relation to the total volume of the contents, and were not found in any of the stomach samples. Mammalian items (muskrat and small rodent) were identified in 19.2 percent of the intestinal samples and in 7.7 percent of the stomach samples.

Aquatic Food Item Tissue Metal Concentrations (Task 2)

Whole body metal concentration means and standard errors from whitefish and sucker collected on Clark Fork and reference sites are found in Table 2 and 3, respectively. Statistical test results (P-values) from comparisons between Clark Fork and reference site tissue metal concentrations in whitefish and sucker are found in Appendix 5. Whole body metal concentrations in brown trout collected at the same Clark Fork and reference sites have previously been reported by Bergman (1993).

Whitefish caught from below Warm Springs Ponds in 1991, and below Warm Springs Ponds and above Turah Bridge in 1992, had significantly higher whole body concentrations of Cd and Pb compared to fish from reference sites (Table 2). Whole body Cu concentrations were significantly greater in 1992 fish from Warm Springs and Turah Bridge, while As concentrations were significantly greater in 1991 fish from below Warm Springs as compared to fish from reference sites.

Sucker collected from below Warm Springs Ponds and above Turah Bridge in 1992 had significantly higher whole body concentrations of Cd, Pb, and Cu compared to suckers collected from reference sites (Table 3). In 1991, insufficient numbers of suckers were collected within comparable size ranges to allow statistical comparison, so they were not analyzed.

Mink Tissue Metal Concentrations (Task 3)

Tissue metal concentration means and standard errors of the means for liver, kidney, and brain from Clark Fork and reference site mink are found in Table 4, 5, and 6. Statistical test results (P-values) from comparisons between Clark Fork and reference site mink tissue metal concentrations are found in Appendices 6, 7, and 8.

Cadmium

Adult liver and kidney Cd concentrations were significantly higher in mink from Warm Springs and in pooled adult samples from Clark Fork sites compared to reference sites (Figure 4, Tables 4 and 5). Liver Cd concentrations in juveniles from pooled Clark Fork sites were higher than for reference sites (Figure 4), and this difference was nearly significant ($P=0.0654$ Appendix 6). Juvenile mink brain Cd concentrations from Warm Springs were elevated above reference sites, and were also nearly significant ($P=0.0517$ Appendix 8).

Lead

Clark Fork mink liver and kidney Pb concentrations were significantly greater than those from reference sites in both age classes, and across all Clark Fork site comparisons (Figure 5, Tables 4 and 5). Brain Pb was significantly higher in adult mink from Warm Springs and in adult mink from pooled Clark Fork sites than in adult mink from reference sites (Table 6).

Copper

Clark Fork mink liver Cu concentrations were significantly greater than reference sites in both age classes, and across all site comparisons (Table 4). Kidney Cu was significantly higher in the Warm Springs juveniles than in reference juveniles (Table 5), and was nearly significantly higher in the comparison between pooled Clark Fork sites and reference sites for juveniles ($P=0.0649$ Appendix 7). Brain Cu was significantly higher in juvenile mink from Warm Springs than from reference sites, and this difference was nearly significant ($P=0.0608$) in the pooled Clark Fork sites juvenile comparison (Table 6 and Appendix 8).

Zinc

Liver Zn concentrations were significantly higher in both adult and juvenile mink from Warm Springs compared to reference sites (Table 4). Concentrations of Zn in mink kidneys were not found to be significantly elevated in Clark Fork mink, although Zn kidney concentrations in adult Warm Springs and pooled Clark Fork adults were nearly significantly higher than from reference sites ($P=0.0579$ and $P=0.0611$ Appendix 7). Brain Zn concentrations in the juveniles from pooled Clark Fork sites were significantly elevated over reference sites (Table 6), while brain Zn concentrations in juveniles from Warm Springs were nearly significantly higher ($P=0.0548$ Appendix 8).

Arsenic

Liver As concentrations were significantly elevated in juvenile mink from all Clark Fork sites compared to reference sites (Table 4). Kidney As concentrations were nearly significantly higher in adult Warm Springs mink ($P=0.0690$) and in combined Clark Fork adults ($P=0.0593$) than in adults from reference sites (Appendix 7). Brain As was also nearly significantly higher in adult mink from Warm Springs ($P=0.0518$ Appendix 8).

Furbearer Sign Survey (Task 5)

Significant differences were found in the amount of furbearer sign between paired Clark Fork and reference sites (Figure 6). Table 7 contains sign per kilometer values for otter, mink, raccoon, and beaver on each of the paired Clark Fork and reference sites. In the fall 1992 sign survey, no otter sign was found on any of the Clark Fork River sites, while sign was found on four of the six reference sites. Otter, mink and raccoon sign were significantly more common on reference sites than on paired Clark Fork sites ($P<0.01$; Table 7). There was no significant difference in the amount of beaver sign observed between paired Clark Fork and reference sites. A statistical comparison was not conducted on spring 1992 sign survey data because of differences in stream flows during this survey.

Riparian Zone Habitat Analysis (Task 6)

There were no significant differences in the relative proportions of the twelve habitat classifications between paired Clark Fork and reference sites (Table 8). Comparisons for habitat classification 6 (upland scrub) between the Clark Fork and reference sites, were nearly significantly different ($P=0.062$), however, in its relative proportion, with a greater occurrence found on reference sites. (See Appendix 1 for descriptions of habitat classifications.)

There were no significant differences in either the mean functional bank height or the median functional bank height between paired Clark Fork and reference sites. There was also no significant difference in the distance to nearest cover between paired Clark Fork and reference sites (Table 9). Finally, there was no significant difference in the relative proportions of the nearest cover types between paired Clark Fork and reference sites (Table 10).

Mink Health Assessment (Task 7)

Necropsies of most mink examined from the 1991-1992 season showed general tissue discoloration, most likely due to animals freezing in the traps and due to frozen storage. Examination of carcasses revealed no gross external or internal deformities. Most animals showed lung discoloration indicative of drowning. External abdominal and internal visceral fat was present to some degree in all mink. No macroscopic parasites were found either

internally or externally.

Most of the mink tissues sampled for histological examination showed signs of autolysis and were distorted by freezing artifact, thereby limiting the detection of most subtle lesions. In spite of this limitation in many of the samples, however, one mink collected from the Clark Fork near the Warm Springs Ponds showed signs of acute nephritis, which is often associated with acute metal injury (Dr. Beth Williams, State Pathologist, Wyoming State Veterinary Laboratory, pers. comm.). Some of the proximal tubules in the renal cortex of this animal contained granular casts, the remnants of proximal tubule cells that died and were sloughed off into the tubule. An accumulation of a proteinaceous fluid in the proximal tubules was suggestive of glomerular or epithelial damage. A lack of evidence of damage to the kidney interstitium suggests acute rather than chronic damage. Several other pathologies were seen with some regularity in the carcasses examined, although none are associated with or suggestive of metal toxicity.

Evaluation of Level of Human Disturbance (Task 8)

<u>Review of Recent Trapping Records</u>

Significant differences exist between the number of otter trapped per river mile from the main river channel and tributaries of the upper Clark Fork compared to the Big Hole, and the Bitterroot rivers during the years 1981 to 1990 (Table 11, Figure 4). Significantly more otter were trapped on both the Big

Hole and the Bitterroot rivers than on the upper Clark Fork. Conversely, there is no significant difference between the number of otter trapped per river mile between the Big Hole and Bitterroot rivers (Table 12).

A statistical comparison between the reported beaver harvest from MDFWP region 2 (which contains the upper and lower Clark Fork, Bitterroot, St. Regis, Clearwater, and Blackfoot rivers and Rock Creek) and region 3 (which contains the Big Hole, Beaverhead, Ruby, Jefferson, Madison, Gallatin, and parts of the Yellowstone and Missouri rivers) for the years 1985 through 1989 indicates that there was no significant difference in the number of beaver trapped from each region on a per unit area basis (Table 13).

Human Populations

According to 1990 U.S. census figures (U.S. Dept. of Commerce 1990), human population numbers differ dramatically between the Clark Fork, Big Hole and Bitterroot valleys. The Big Hole valley has the lowest population (1,982), followed by the Clark Fork valley (8,004), and the Bitterroot valley (29,803).

Livestock Numbers

In 1992, livestock numbers in the upper Clark Fork drainage from Warm Springs to Clinton were estimated at between 20,000 and 25,000 (David Streufert, Powell County Extension Agent, pers. comm.). This is slightly more than the 1992 estimate of between

15,000 and 18,000 cattle in the Big Hole River drainage from Jackson to Glen (John E. Maki, Beaverhead County Extension Agent, pers. comm.), and is slightly less than the 33,100 estimated animals in the Bitterroot drainage from Darby to Lolo (G. Rob Johnson, Ravalli County Extension Agent, pers. comm.).

All three rivers have similar although slightly different drainage areas, with the drainage area of the Clark Fork at Turah Bridge at 3,641 mi^2, the Big Hole near Melrose draining 2,476 mi^2, and the Bitterroot near Missoula draining 2,814 mi^2 (USGS 1992). In terms of the relative grazing intensity as expressed by the number of livestock per square mile of drainage, the upper Clark Fork and Big Hole drainages have similar values (6.9 and 7.3 animals/mi^2), while the Bitterroot contains substantially more livestock (11.8 animals/mi^2).

Irrigation Demands

The Clark Fork, Big Hole, and Bitterroot rivers have similar irrigation demands. Approximately 100,000 acres of agricultural land are irrigated upstream of Turah Bridge on the Clark Fork (USGS 1990). This is comparable to the 136,000 and 111,000 acres irrigated on the Big Hole upstream of Melrose, and on the Bitterroot upstream of Missoula, respectively (USGS 1990). Since the Clark Fork and the Big Hole have a similar yearly discharge and similar irrigation demands, the amount of water remaining in each river throughout the year should also be similar.

Distance to Highway

The Clark Fork is greater than 100 m of I-90 along approximately 156 km (97 mi) of its total 196 km (122 mi) length from Warm Springs to the Milltown Reservoir. The longest continuous stretch along the Clark Fork within 100 m of I-90 is approximately 4.4 km (2.7 mi).

Comparison of Tissue Residue Criteria for Consumption of Fish by Mink and Otter with Metal Concentrations in Clark Fork and Reference Site Fish (Task 9)

Table 14 shows the Cd and Pb tissue residue criteria values obtained from the Newell model. Fish tissue residue criteria values were slightly higher for otter than mink for both Pb (89 and 67 ug/kg diet for otter and mink respectively) and Cd (533 and 400 ug/kg diet for otter and mink respectively).

These criteria were compared to the mean dietary exposure concentration in fish from below Warm Springs Ponds and from reference sites in Table 15. The dietary exposure concentrations (expressed as wet weight) presented in Table 15 were calculated from mean metal concentrations (dry weight) for suckers (Table 3) and brown trout (Bergman 1993) collected from below Warm Springs Ponds and from the reference sites, using an average wet weight for fish of 72 percent determined in this study. The dietary composition of trophic level 3 (sucker) and trophic level 4 (brown trout) included in Table 15 for mink and otter are based on the dietary composition for these species specified by USEPA (1993) in procedures for calculation of water quality criteria

for protection of piscivorous wildlife. In spite of USEPA's use of 100 percent trophic level 3 fish as the dietary composition for mink, we have also presented dietary exposure concentrations of Cd and Pb for mink assuming only 50 percent trophic level 3 fish (i.e., and 50 percent non-contaminated diet), since mink are more opportunistic than otter and likely consume less than 100 percent fish during most of the year.

Based on these calculations, the dietary exposure of Pb to mink consuming 50 percent trophic level 3 fish from the Warm Springs Ponds site (51 ug Pb/kg diet) approached the Pb criterion (67 ug Pb/kg diet) (Table 15). Lead exposure to mink consuming a diet of 100 percent trophic level 3 fish from the Warm Springs Ponds site (102 ug Pb/kg diet), and otter consuming a diet of 50 percent trophic level 3 and 50 percent trophic level 4 fish from the Warm Springs Ponds site (157 ug Pb/kg diet), exceeded their respective Pb criterion. Cadmium exposure from diets of Warm Springs Ponds site and reference site fish did not exceed their respective criteria for either mink or otter (Table 15).

DISCUSSION

Trapping Record Review

This research was initiated because of the observation that the number of river otter trapped from the entire upper Clark Fork drainage (only 3 trapped over a 13 year period) was strikingly low compared to adjacent drainages (Figure 4). Indeed, there appears to be a 'hole' in the map showing otter trapping records for western Montana in the area corresponding to the upper Clark Fork and its tributaries. One obvious explanation to this phenomenon would be a disparity in the amount of trapping effort between the upper Clark Fork and the surrounding drainages.

In virtually all cases, otters are trapped incidentally in beaver sets. Otter are not actively pursued for several reasons, the most important of which is that state trapping regulations allow a maximum of one otter taken per trapper per year. This one animal allowance exists mainly to permit trappers a legal means by which to sell any otter captures that are incidental to beaver trapping (Howard Hash, MDFWP Furbearer Biologist, pers. comm.). The number of otter trapped in a given area, therefore, is a reflection of effort in beaver trapping in that area. One would therefore expect two areas with similar numbers of beaver trapped to also produce a similar number of incidental otter captures, if there were no differences in otter numbers between the two areas.

This hypothesis was tested between MDFWP administrative

regions two (which contains the Clark Fork) and three which lies immediately south of the Clark Fork valley. Region three is somewhat larger than two, and after compensating for differences in area, it is apparent from data presented in Table 13 that the two areas have similar beaver harvests, based on the number of animals caught over the five years examined.

This review of MDFWP trapping records was further focused to examine the number of otter captured on a per river mile basis between the upper Clark Fork and two adjacent river systems: the Bitterroot River immediately to the west of the Clark Fork, and the Big Hole River drainage immediately south. Since many beaver (and therefore otter) are not trapped directly from the main river channel but rather from small side streams where trap placement is easier, any meaningful examination of otter numbers on a given river must include the tributaries of that river as well. Based on this analysis, significant differences in otter harvests are seen (Tables 11 and 12). Significantly fewer otter were trapped on the upper Clark Fork than on the Big Hole and Bitterroot rivers. No statistical difference was seen between the number of otter trapped between the Bitterroot and Big Hole rivers. Thus, the reason fewer otter are trapped on the upper Clark Fork is no doubt due to a reduced or largely absent river otter population.

Sign Survey for Otter, Mink, Raccoon, and Beaver

To confirm the apparent absence of otter on the Clark Fork, and to investigate the possibility that other semi-aquatic mammals might also demonstrate reduced populations on the Clark Fork, a more quantitative and scientific examination of species abundance was undertaken to compare the Clark Fork and paired reference sites. Sign surveys conducted in the fall of 1992 on paired sites of the Clark Fork and Big Hole rivers identified differences in the abundance of animal sign for several piscivorous species including otter, mink, and raccoon. Abundance of otter sign was significantly elevated on the reference sites above Clark Fork levels ($P<0.01$; Table 7), with sign found on four of six reference sites and no sign found on any of the Clark Fork sites. The lack of otter sign on several of the paired reference sites was to be expected, since otter are highly mobile (Melquist and Hornocker 1983, Jenkins 1980), utilizing different areas of their habitat at different times of the year, primarily due to changes in the availability of food resources (Melquist and Hornocker 1983, Jenkins and Burrows 1980, Erlinge 1967), and due to dispersal by young animals (Melquist and Hornocker 1983, Jenkins 1980). Otter sign was observed on the Big Hole as far upstream as Wisdom during the spring 1992 survey, indicating that the entire river is utilized by otter.

Spatial utilization of local habitat by otter can also change rapidly, with animals preferring to move continually within their home range but returning often to an activity center

(Melquist and Hornocker 1983). Kruuk et al. (1986) argue that scat is normally found in specially selected habitat, but that adjacent unmarked areas are also actively used by otter. This was evident on two Big Hole reference sites in close proximity to each other (REF 5 and 6). These areas were separated by less than 2 kilometers, but one area (REF 6) contained abundant otter sign while the other (REF 5) contained no sign at all. A survey of the same sites the following year (late summer 1993) identified sign on five of six reference sites, with again no sign found along the upper Clark Fork sites (data not shown).

The fact that no otter sign was found in either the spring or fall 1992 or the summer 1993 surveys on any of the Clark Fork sites strongly supports the view of MDFWP and Bureau of Land Management (BLM) area biologists, and local trappers and ranchers in the area, all of whom agree that otter are absent or only transient on the upper Clark Fork River. Otters appear to explore the upper Clark Fork since occasionally one is captured. Young dispersing otter tend to travel the longest distances of all age classes in search of unoccupied habitat (Jenkins 1980), so it is likely that these captures were young animals attempting to establish their own territories. The Clark Fork exhibits good potential as new territory for otters since it is unpopulated by resident otters (thereby eliminating any intraspecific competition), and is in close proximity to viable otter populations both down stream, and in adjacent drainages (such as the Bitterroot and Big Hole rivers). In spite of this, however,

otters have not been successful at re-establishing themselves on the upper Clark Fork.

Additionally, both mink and raccoon sign were significantly lower ($P \leq 0.05$; Table 7) on the Clark Fork compared to reference sites. This reduction in mink sign is unlikely to be a result of the previous winters' trapping effort, since both the Big Hole and Clark Fork study areas are trapped along their entirety by local trappers. Both rivers would therefore be expected to exhibit a similar reduction in mink sign.

The significantly lower amount of raccoon sign on the Clark Fork was expected if a general depression in numbers of piscivorous species exists on the upper Clark Fork as proposed, and further strengthens our argument.

Differences in the amount of beaver sign were not significant between paired Clark Fork and reference sites (Table 7). This would be expected if metal contamination within the CFR had reduced populations of semi-aquatic mammals through either a reduction in the populations of aquatic prey species, or through direct toxicity from ingestion of contaminated prey. Herbivores like the beaver, not dependant on aquatic animals as food, would therefore not be expected to show a similar reduction in abundance.

Otter and beaver are considered to be closely associated species (Melquist and Hornocker 1983) with beaver enhancing habitat for otter through their activities. In addition to dam building on tributaries, which improves fish habitat and

therefore the habitat quality for otter (Novak 1987), beavers also improve riparian habitat for otter through their excavation of bank dens, which also serves as a suitable escape, resting, and litter rearing cover for otters (Dubuc et al. 1990, Melquist and Hornocker 1983). Beavers also improve the fish habitat and therefore otter food supply by deepening holes on the main river channel at beaver den entrances. In a study exploring which variables were the most effective at predicting otter presence within a drainage, the presence of beaver was found to be the most reliable indicator (Dubuc et al. 1990). Since the amount of beaver sign between the Clark Fork and reference sites are not significantly different, and since the presence of otter is closely associated with the presence of beaver, it is reasonable to conclude that the upper Clark Fork's physical habitat should be conducive to supporting an otter population of roughly similar size.

<u>Additional Possible Factors Affecting Otter Presence Other Than Direct Toxicity</u>

Several factors other than the direct effects of metal toxicity could be preventing otter from re-establishing a viable population on the upper Clark Fork including a lack of adequate structural habitat for both escape and litter rearing, the level of human disturbance along the river, and a lack of adequate food supply.

Habitat Characteristics

Our habitat studies found no significant differences in the habitat classifications, cover types, distance to nearest cover, or functional bank heights between selected Clark Fork and the paired reference sites (Tables 8, 9, and 10). This indicates that the physical habitat structure is similar for aquatic and semi-aquatic mammals between the paired sites. As discussed earlier, the abundance of beaver sign found on the Clark Fork infers an abundance of bank dens - prime escape and litter rearing cover for otter (Melquist and Hornocker 1983). Therefore we must conclude that adequate cover for escape, concealment, and litter rearing is not a factor limiting otter populations on the Clark Fork.

Human Disturbance

In terms of both estimated total numbers and density of livestock, the Big Hole and upper Clark Fork river valleys are similar, while the Bitterroot valley appears to contain more animals at a higher density. Assuming that each river has a similar proportion of the total number of livestock found within its riparian zone, the Big Hole and Clark Fork rivers must also have similar grazing intensities along their banks, while the Bitterroot has substantially more. Under these assumptions it can be concluded that grazing impacts along the Clark Fork are similar to or less than that found in adjacent river systems that contain otter, and that the grazing intensity along the Clark

Fork does not appear responsible for the absence of otter.

The Clark Fork, Big Hole, and Bitterroot rivers also have similar irrigation demands. Since the Clark Fork and the Big Hole rivers have a similar yearly discharge and similar irrigation demands, the amount of water remaining in each river must also similar.

According to 1990 U.S. census figures (by county division, not including the city of Missoula), the human population of the Clark Fork valley is of intermediate size compared to that of the Big Hole and Bitterroot valleys (U.S. Dept. of Commerce 1990). The Bitterroot River valley has a much larger human population (29,803) than the upper Clark Fork valley (8,004), with the area around Hamilton alone containing over 12,000 people. Since most of the people included in these numbers live in cities located directly along their respective rivers, these figures are a relatively accurate reflection of the level of disturbance by human populations along each river. The fact that the Bitterroot River still contains otters indicates that a human population of the size found within the upper Clark Fork valley, does not preclude a viable otter population.

Other evidence that otter are not automatically disturbed by close proximity to development is seen in the MDFWP trapping records as presented in Figure 4. The two areas of the state with the highest otter harvest are both in close proximity to areas with high levels of human disturbance. One of these is the area immediately adjacent to the town of Kalispell, population

11,917 (U.S. Dept. of Commerce 1990), the other is in the Three Forks area immediately adjacent to I-90. In addition, Zackheim (1982) found the Jefferson River near the town of Whitehall on I-90 as the area with the greatest otter activity of all southwestern Montana rivers examined. Our observations confirm this, with otter sign observed in close proximity to the interstate (I-15) and state highways along the Big Hole River.

While otter probably avoid occupation of those stretches of the Clark Fork in close proximity to I-90, there appears to be adequate stretches (156 km or 97 mi) of river refugia. Interestingly, the reference site which had the greatest otter sign during the fall 1992 sign survey (REF 6), is never greater than 1.7 km away from I-15, and is less than 300 m away from I-15 over one third of its length. Otter sign was found on stretches of this site less than 200 m from the interstate. Trapping records from MDFWP indicate that a number of otter have been trapped along the middle Clark Fork from Frenchtown to St. Regis, a stretch of river that closely parallels I-90. Even more striking are the number of otter trapped along the St. Regis River, which runs along side the interstate for most of its length. The ability of otter to survive and thrive in other rivers that closely follow major state highways or interstates, support the conclusion that those portions of the Clark Fork that flow relatively close to the road do not constitute a barrier to travel.

The notion that vehicles travelling along the highway or

frontage road are a significant source of mortality, and may explain the absence of otter on the upper Clark Fork is doubtful, since reports of such encounters are non-existent. Such roadkills would also be easily identifiable by any competent biologist, trapper, or outdoor enthusiast, and their existence quite conspicuous. In areas with abundant otters, motor vehicles could become a significant source of mortality. However, the absence of a viable otter population in the first place precludes the possibility that this is the case on the upper Clark Fork.

Dams such as the one located at Milltown do not appear to prevent otter from moving into the upper Clark Fork, since an otter is caught about once every four or five years by a local trapper. Several dams also exist further down the Clark Fork, which contains otter populations on either side of the dam. Otters are known to make overland crossings of up to 3 km, and have even been documented traversing mountains passes (Melquist and Hornocker 1983). The Milltown dam is therefore not considered a barrier to otter movement.

Reduced Food Resources

Zackheim (1982) found that otter scat examined from the Big Hole contained (by frequency of occurrence) primarily sucker (60%), whitefish (45%), sculpin (<u>Cottus bairdi</u>) (40%) and trout (23%) remains. This agrees with studies of otter scat in similar habitat in Idaho that list sucker and whitefish as two of the most common food items (Melquist and Hornocker 1983). The

particular species of fish comprising the greatest portion in the diet seems to be determined primarily by species abundance and availability (Melquist and Hornocker 1983).

Other studies on the subject have determined that mink are more opportunistic and do not rely as heavily on fish as a staple food item as otter (Eagle and Whitman 1987, Melquist and Dronkert 1987). The extent to which fish are found in the diet is largely determined by availability, but can make up nearly 100 percent of the diet during certain times of the year, such as when fish are spawning and are more vulnerable to capture (Melquist et al. 1981), or when fish are moribund as undoubtedly occurs during the large die-offs seen on the upper Clark Fork. Raccoons are also opportunistic feeders that will eat fish if it is readily available (Sanderson 1987).

Chapman (1993) reports that trout populations are significantly lower in the upper Clark Fork both in terms of numbers and biomass compared to paired reference sites, and that Silver Bow Creek contains no fish at all. Trout biomass on reference sites are about 12 times that of the Clark Fork. Interestingly, the Clark Fork sites had more suitable fish habitat per unit area than reference sites, and that based on this and the river's specific conductance, the Clark Fork should have a greater standing crop of trout than reference sites. Chapman (1993) concludes that the reduction in trout is the result of metal contamination in the river. Whitefish numbers were also generally lower on the Clark Fork, with reference sites

having about twice as many whitefish as Clark Fork sites.

A reduction in trout and whitefish on the Clark Fork would undoubtedly have significant effects on the ability of the river to support otter as well as other piscivorous species. If overall fish biomass was reduced beyond a minimum critical level, obligate piscivores such as otter would be the first species expected to disappear from the area. Populations of facultative piscivores such as mink and raccoon would be expected to demonstrate a reduction in population size since the overall available prey base is reduced. This is the most plausible explanation for the absence of a viable otter population, and the reduction observed in populations of mink and raccoon along the upper Clark Fork River. Furthermore, since the Clark Fork would act as the main travel route by which otter would explore associated tributaries for re-colonization, the inadequacy of the Clark Fork to support otter would severely inhibit the re-establishment of this species throughout the remainder of the upper Clark Fork drainage.

<u>Metal Contamination as an Explanation for the Absence of Otter on the Upper Clark Fork</u>

(Note: Tissue metal concentrations reported in the literature in terms of wet weight were multiplied by 3.5 (i.e., assumes 72 percent wet weight) to convert into their dry weight equivalent concentrations for comparison with metal

concentrations found in this study.)

Fish Residues

Whole body metal concentrations of Cd, Pb, and Cu are significantly higher in whitefish and sucker (this report, Tables 2 and 3) and in brown trout (Bergman, 1993) from the upper Clark Fork compared to reference sites. The highest concentrations of the five metals examined are consistently found in suckers collected from the Clark Fork below Warm Springs Ponds.

Mean Clark Fork sucker Cd values are as high as 7.6 times the national average value of 100 ng/g dw (Schmitt and Brumbaugh 1990). Similarly, Clark Fork whole body Pb and Cu means are up to 5.4 and 10.8 times the national average respectively (Schmitt and Brumbaugh 1990). Whole body Clark Fork Zn concentrations are similar to the national average, although small size class sucker from below Warm Springs Ponds had noticeably higher Zn concentrations. Whole body Cd, Pb, Cu, and Zn concentrations in whitefish and sucker from reference sites are approximately the same as, or are well below national average values for these metals (Schmitt and Brumbaugh 1990).

Mink Tissue Metal Concentrations

<u>Cadmium</u>

Mean kidney cadmium concentrations from the Clark Fork (Table 5) resemble values from mink trapped in other industrialized areas. The highest mean Cd concentration found in

this study is in adult Clark Fork kidneys (2752 ng/g dw), and is similar to values from mink collected from the highly industrialized region near Sudbury, Ontario (Wren et al. 1988), and from mink collected near the Coeur d'Alene River, downstream from a lead smelter (Blus and Henny 1990, Blus et al. 1987). Mean adult kidney concentrations from reference sites are also similar to values from mink trapped in relatively uncontaminated areas (Blus and Henny 1990, Wren et al. 1988, Blus et al. 1987, Ogle et al. 1985). Renal cadmium concentrations above 46 ug/g dw represent a significant hazard in higher trophic level organisms (Eisler 1985).

Mean liver Cd concentrations in mink from reference sites (Table 4) are similar to values reported in mink from relatively uncontaminated areas (Wren et al. 1988, Ogle et al. 1985, Frank 1986). The adult Clark Fork mean liver Cd concentration is slightly higher than that reported by Wren et al. (1988) in mink collected near the Sudbury, Ontario area. Based on the available literature, mink are able to maintain higher cadmium tissue concentrations than those found in this study.

It appears that Clark Fork mink are not at direct risk from cadmium toxicity alone, although the possibility exits for combined effects from multiple metal interactions and/or environmental variables such as poor nutrition from a reduced prey base, or weather extremes. Lead is known to interact synergistically with cadmium in its teratogenic effects (Tsuchiya 1986).

Lead

Mean Clark Fork mink liver and kidney Pb concentrations are significantly higher than from reference sites in both adult and juvenile mink (Tables 4 and 5), although the highest mean Pb was found in livers from Deer Lodge (1,093 ng/g dw). Ogle et al. (1985) found liver and kidney Pb concentrations in juvenile mink collected throughout Virginia similar to our reference mink (approximately 200 ng/g dw). Mean liver Pb concentrations of mink trapped near Sudbury, Ontario (Wren et al. 1988) were similar to Clark Fork values, while mink collected downstream from the lead smelter at Kellogg, Idaho had a much higher mean liver lead concentrations (14.35 ug/g dw) (Blus et al. 1987). Although Blus et al. (1987) concluded that Pb contamination was at least partially responsible for reduced mink populations, it is apparent that mink are capable of withstanding high Pb tissue concentrations. Tissue lead concentrations above 35 ug/g dw are associated with lead toxicity in mammals (Osweiler et al. 1978), but even concentrations below 17.5 ug/g dw have been associated with behavioral and physiological abnormalities (Zook et al. 1972, Clarke 1973). In comparison to our reported values, it appears that mink are probably not directly threatened by Pb poisoning. Lead, however, is known to have deleterious behavioral effects on young animals at tissue concentrations that produce no overt clinical signs in adults. Also, lead and cadmium are known to be synergistic in their effects (Tsuchiya 1986), and it is therefore possible that injury from a combined

effect still exists.

Copper

Liver Cu concentrations are significantly higher in Clark Fork mink across all age class and site comparisons (Table 4). Mean liver copper concentrations of Clark Fork adult and juvenile mink are comparable to concentrations found in mink collected throughout Virginia (Ogle et al. 1985), and lie intermediate to values reported in mink collected from areas of Ontario with moderate and high anthropogenic metal inputs (Wren et al. 1988). Liver copper means from Clark Fork mink are slightly above those of mink trapped near the lead smelter complex on the Coeur d'Alene River in Idaho (Blus et al. 1987). In a copper feeding study, adult mink remained apparently healthy with liver concentrations as high as 479 ug/g dw, although kit mortality increased and litter mass decreased in one of the high dietary Cu groups (Aulerich et al. 1982). The highest mean liver Cu concentration from this study was found in Deer Lodge mink (56 ug/g dw). In general, liver and kidney copper concentrations reported in the literature have a wide range of values, with reported liver concentrations reaching as high as 193 ug/g dw in wild caught mink (Ogle et al. 1985).

Mean kidney Cu concentrations are significantly higher only in juvenile mink caught near Warm Springs Ponds (23 ug/g dw) as compared to mink from reference sites (Table 5). Kidney Cu levels reported in the literature are generally lower than

respective liver values (Wren et al 1988, Ogle et al. 1985, Aulerich et al. 1982). Mean kidney copper concentrations in wild mink from these studies are similar to those seen in Clark Fork and reference site mink.

Zinc

Mean liver zinc is significantly elevated in both adult (103 ug/g dw) and juvenile (117 ug/g dw) mink from Warm Springs Ponds as compared to reference sites (Table 4). Clark Fork values are similar to those found in mink collected near the lead smelter at Kellogg, Idaho (Blus et al. 1987), from Virginia (Ogle et al. 1985), and from Ontario (Wren et al. 1988). Mink feeding studies with 1500 mg/kg ww dietary Zn achieved liver Zn concentrations as high as 469 ug/g dw with no histological lesions in either the liver, kidney or pancreas, and no changes in hematological parameters (Aulerich et al. 1991).

Mean zinc kidney concentrations in mink from the Clark Fork (73 - 89 ug/g dw) are not significantly different from reference site mink (Table 5) and are comparable to the mean values of wild caught mink from two other studies in Ontario and Virginia (Wren et al. 1988, Ogle et al. 1985). Mink fed diets containing 121 mg Zn/kg ww had a mean kidney zinc concentration of 550 ug/g dw with a concomitant loss in weight and atrophied pancreas (Mejborn 1990). Aulerich et al. (1991) however, fed dietary zinc concentrations as high as 1500 mg Zn/kg ww without similar observations. Pancreas concentrations in both studies were

similar (approximately 110 ug/g ww) although mean kidney Zn was somewhat lower in the latter study (469 ug/g dw). It appears then, that copper and zinc levels, although significantly elevated compared to mink from reference sites, do not pose a toxicological threat to Clark Fork mink.

Mink Tissue Histology

One adult mink (#195), which was caught along the Clark Fork on the Warm Springs Ponds Game Management Area, was the only animal to show any histologic signs associated with metal injury. This individual had an elevated kidney cadmium level (980 ng/g dw) compared to the reference site mean for the adult age class (434 ng/g dw), although higher kidney concentrations were also observed in other adult and juvenile Clark Fork mink as well. It is quite possible that this type of injury is more prevalent in the Clark Fork mink, but was not detected due to the quality of the tissue samples. Kidney nephron damage is characteristic of cadmium injury, but a considerable number of nephrons (approximately 75 percent) must be damaged before clinical signs of renal failure are manifest. It is possible, therefore, that this animal was not significantly affected by this injury, although the injury's existence is significant.

Comparison of Tissue Residue Criteria for Consumption of Fish by Mink and Otter with Metal Concentrations in Clark Fork and Reference Site Fish

Based on the tissue residue criterion model, lead concentrations in the diet of mink consuming fish from below Warm Springs Ponds are sufficiently high to suggest the possibility of lead injury to mink populations on the upper Clark Fork River. The tissue residue criterion (i.e., a safe metal concentration in the diet) for dietary Pb exposure to mink (67 ug/kg diet; Table 14) is slightly higher than the calculated dietary exposure concentration for Pb (51 ug Pb/kg diet; Table 15), assuming the mink are consuming 50 percent of their daily food intake as suckers (trophic level 3 fish) from the Clark Fork River below Warm Springs Ponds. However, if suckers from below Warm Springs were to constitute 100 percent of mink diets, the calculated dietary intake (102 ug Pb/kg diet) would exceed the 67 ug/kg diet tissue residue criterion. Thus, the extent of injury expected from Pb in the diet of mink on the upper Clark Fork River depends on the proportion of fish (suckers or fish with similar Pb concentrations) in the diet. The U.S. EPA (1993) recommends that estimates of mink dietary exposure be based on consumption of 100 percent trophic level 3 fish (i.e., suckers or whitefish in the present study), but Newell et al. (1987) conclude that, overall, fish probably constitute between 30 and 50 percent of food consumption in mink. In our study the percent frequency of occurrence of fish was 61.5 percent in mink intestinal samples and 11.5 percent in mink stomach samples (Table 1), although this

measure may underestimate the importance of fish consumption as a proportion of the total biomass in the diet.

Therefore, the actual exposure of mink to dietary Pb on the upper Clark Fork may be somewhat higher or somewhat lower than the calculated Pb tissue residue criterion depending on such factors as seasonal changes in dietary makeup and the extent of Pb contamination in non-fish food sources such as muskrat, aquatic invertebrates, etc.

For otter, on the other hand, comparison of the Pb tissue residue criterion with probable dietary exposure concentrations suggests that otter are at greater risk of Pb poisoning from consumption of fish from the upper Clark Fork River, but not from consumption of fish from reference rivers. As shown in Table 15, the calculated Pb dietary exposure concentration for otter consuming 50 percent trophic level 3 fish and 50 percent trophic level 4 fish from below Warm Springs Ponds (157 ug Pb/kg diet) is substantially greater than the Pb tissue residue criterion for otter (89 ug Pb/kg diet). In the case of otter, the assumption of 100 percent fish consumption, with 50 percent from each of trophic level 3 (e.g., sucker) and trophic level 4 (e.g., trout) fish, as recommended by U.S.EPA (1993), is reasonable since otter are known to consume close to 100 percent of their diet in fish and other aquatic organisms (Melquist and Dronkert 1987). If anything, the calculated dietary Pb exposure concentration for otter on the upper Clark Fork River presented in Table 15 is probably an underestimate of true Pb exposure to otter if they

were present, since large aquatic invertebrates that are also a favored food item of otter are likely to have even higher Pb concentrations than sucker or brown trout.

The tissue residue criteria calculated for dietary Cd exposure to both mink and otter (Table 14) are four to ten times higher than the dietary exposure concentration expected from consumption of fish from the Clark Fork River below Warm Springs Ponds (Table 15). This suggests that Cd concentrations in Clark Fork fish are not high enough, taken alone, to cause deleterious effects on viability of mink or otter consuming a 100 percent diet of Clark Fork fish. However, the possibility of synergistic effects of Cd and Pb (Tsuchiya 1986) as well as other metals in the diet of mink or otter can not be ignored.

For both mink and otter, the additional indirect effects of reduced prey base on the Clark Fork River, as compared to reference sites, would exacerbate the direct toxic effects of Pb, Cd or other metals in the diet. And reduced fish populations on the Clark Fork River, as compared to reference sites, has already been documented along with a cause-effect relationship of these population reductions with metal contamination from mining (Lipton 1993).

CONCLUSIONS

A number of conclusions are warranted from this study in combination with related information in the published literature:

1. A viable otter population is absent from the upper Clark Fork River, based on complete absence of sign, information from MDFWP and BLM personnel as well as local trappers and ranchers, and historical trapping records for otter, while they are present on all comparable rivers in western Montana.

2. Otter, mink, and raccoon abundance is significantly reduced on the upper Clark Fork River compared to paired reference sites.

3. Habitat structural features, which are important for otter and other piscivorous mammals in the riparian zone along the upper Clark Fork River, are identical (indistinguishable statistically) to the habitat structural features on paired reference sites on the Big Hole River, where otter, mink, and raccoons are more abundant.

4. The levels of human disturbance on otter and other piscivorous mammals caused by trapping, grazing, irrigation demands, proximity to highways and human populations appear to be similar or less severe in the upper Clark Fork valley as compared to similar river valleys in western Montana that currently contain otter.

5. Reductions in trout and whitefish populations due to metals (Chapman 1993) have reduced the prey base for all piscivorous mammals on the upper Clark Fork River, with otter being the most severely affected due to their nearly complete reliance on a diet of fish.

6. Whole body concentrations of Pb, Cd, and Cu are significantly elevated in fish from the upper Clark Fork River as compared to fish from reference sites.

7. Metal residue concentrations for Pb, and sometimes Cd, Cu, Zn and As are significantly elevated in liver, kidney, and brain tissues from mink trapped on the upper Clark Fork River as compared to tissues from mink trapped from reference sites, and are comparable to elevated metal residues in tissues of mink collected in North America habitats contaminated with anthropogenic metal inputs.

8. Tissue histology suggests the possibility that metal-related cellular injury occurs to kidney proximal tubule epithelium.

9. Dietary exposure concentrations for Pb in mink consuming fish from the upper Clark Fork River, exceed the Pb tissue residue criterion (a safe dietary intake concentration of Pb), assuming that mink consume more than about 65 percent of their diet as suckers from below Warm Springs Ponds.

10. Dietary exposure concentrations for Pb in otter consuming fish from the upper Clark Fork River exceed the safe Pb tissue residue criterion, based on an estimate of probable exposure from consumption of 50 percent suckers and 50 percent trout from below Warm Springs Ponds.

11. Dietary exposure concentrations for Cd in the diets of mink and otter, though below the respective safe tissue residue criteria for Cd, may contribute to metal toxicity in mink and otter through synergistic interactions with Pb.

All of the above findings from this study and related studies, taken together in a reasonable weight-of-evidence analysis, support an overall conclusion that the observed absence of otter on the upper Clark Fork River is the direct result of past and present environmental metal contamination. Additionally, the findings from this study also support a conclusion that significantly reduced populations of mink and raccoon on the upper Clark Fork River are also directly related to past and present environmental metal contamination. For all piscivorous mammals in this study (otter, mink, and raccoon) the reduced prey base of fish populations on the upper Clark Fork River caused by metal contamination is probably the primary cause of this reduction with elevated tissue metal concentrations

undoubtedly contributing to the overall effect. Furthermore, environmental metal contamination in the upper Clark Fork River has undoubtedly affected the ability of all tributaries within the upper Clark Fork River drainage to support otter, since the Clark Fork would be the main travel route between and into these areas. As water quality and fisheries within the upper Clark Fork improve, it is possible, but not inevitable that this river will once again be capable of supporting a viable otter population.

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Figure 1. Locations of mink collection areas (arrows) along the upper Clark Fork River and reference sites. Clark Fork sites included: (1) Silver Bow Creek just above Warm Springs Ponds to Racetrack Creek; (2) Deer Lodge to Garrison; (3) just below Drummond to Clinton. Reference sites included: (4) upper Big Hole River from Toomey Creek to Fishtrap Creek; (5) upper Rock Creek near Kaiser Lake turnoff; (6) lower six miles of Rock Creek near confluence with Clark Fork; (7) upper Mill Creek at Mill Creek Falls.

Figure 2. Whitefish, sucker, and trout collection areas. Clark Fork sites included: (1) below Warm Springs Ponds; (2) above Turah Bridge. Reference sites included: (3) Sawmill fishing access (Rock Creek); (4) Glen fishing access (Big Hole River). All fish were collected during August 1991 and May 1992.

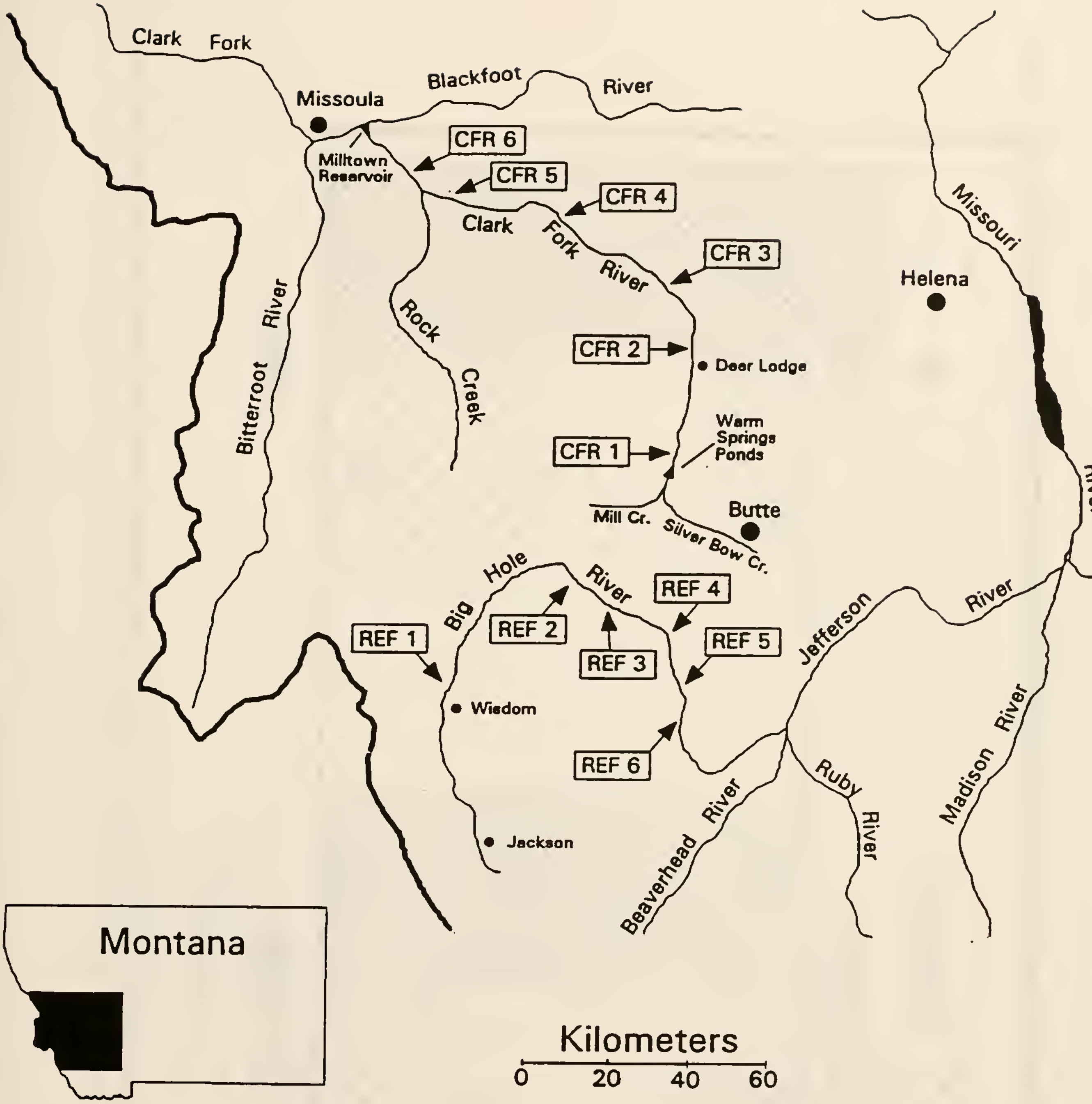

Figure 3. Locations of paired Clark Fork and reference river reaches used in the sign survey for semi-aquatic mammals (Task 5) and the riparian zone habitat analysis (Task 6).

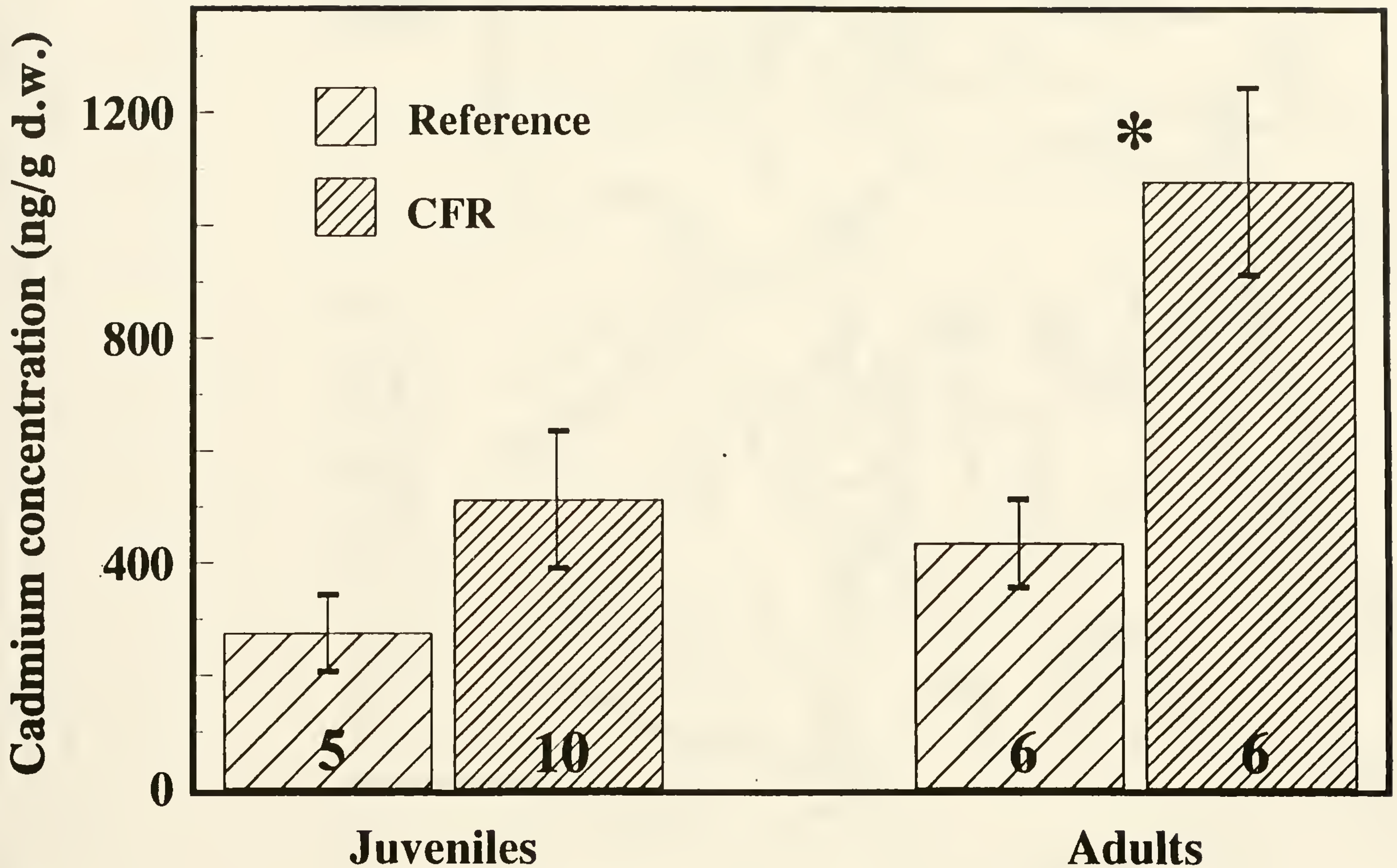

Figure 4. Adult and juvenile liver cadmium residues (mean $\pm$ 1 SEM) in mink collected from Clark Fork River and reference sites during 1991-92 field season.

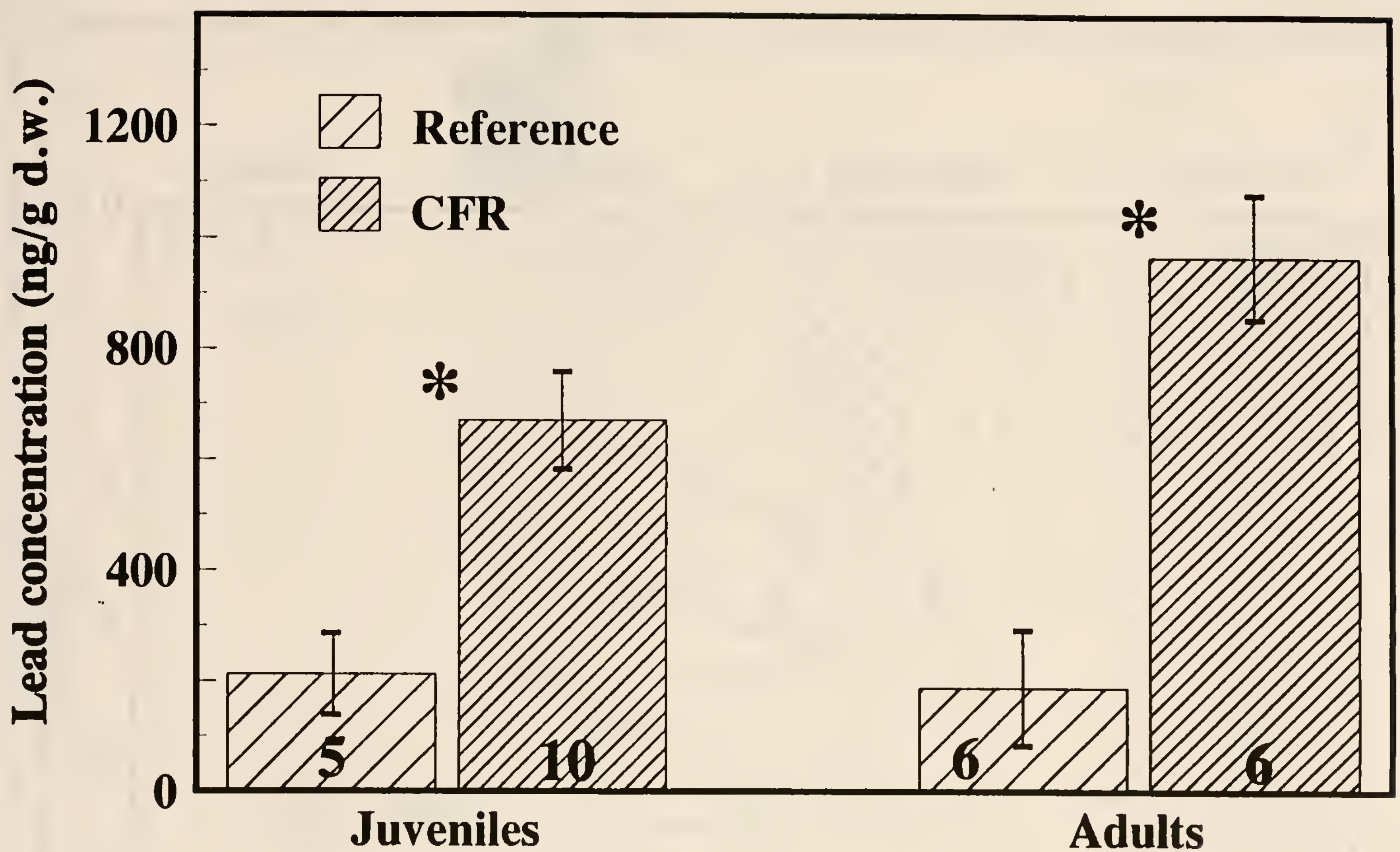

Figure 5. Adult and juvenile liver lead residues (mean $\pm$ 1 SEM) in mink collected from Clark Fork River and reference sites during 1991-92 field season.

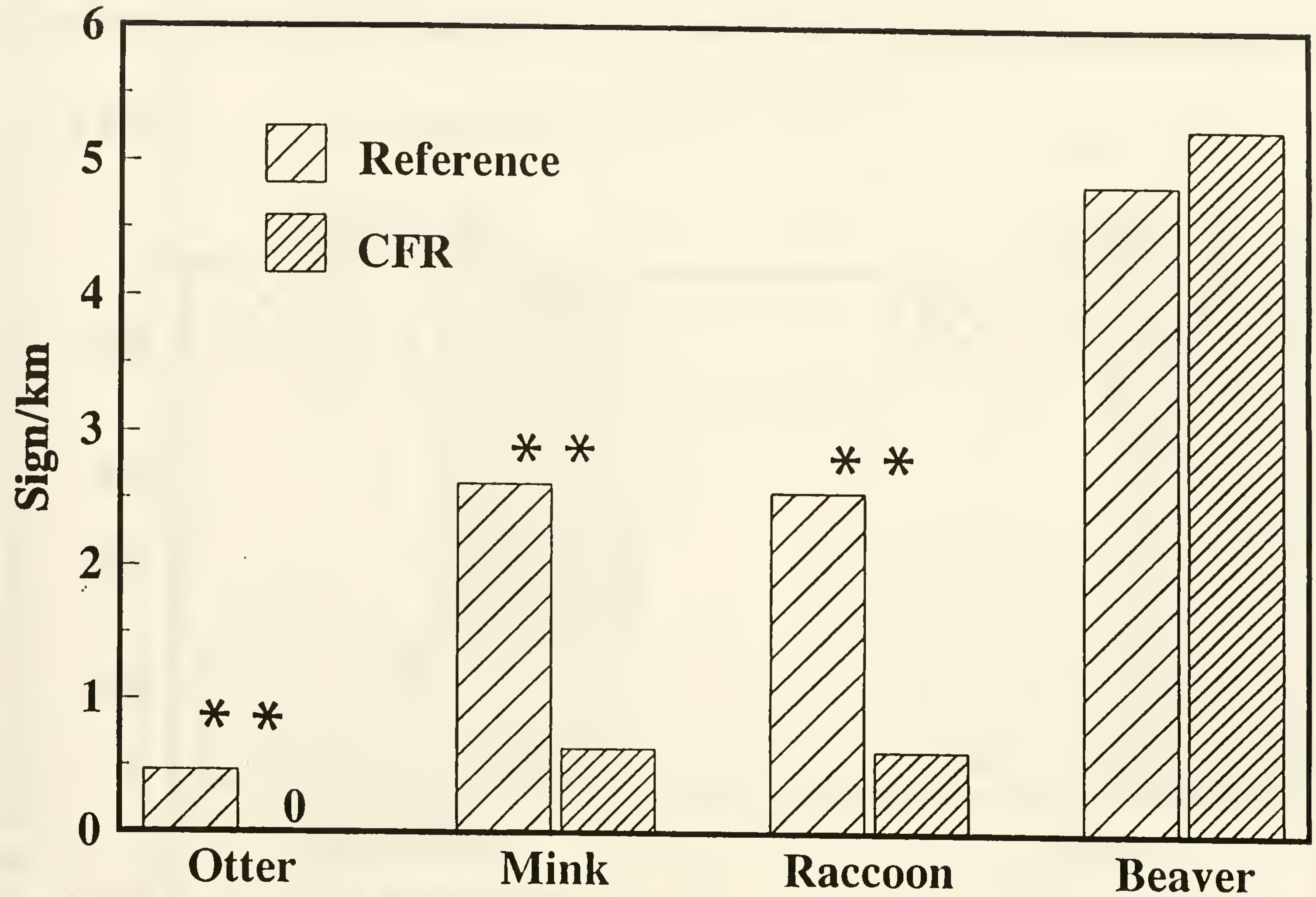

Figure 6. Abundance of otter, mink, raccoon and beaver sign on six paired Clark Fork River and reference sites during the fall of 1992.

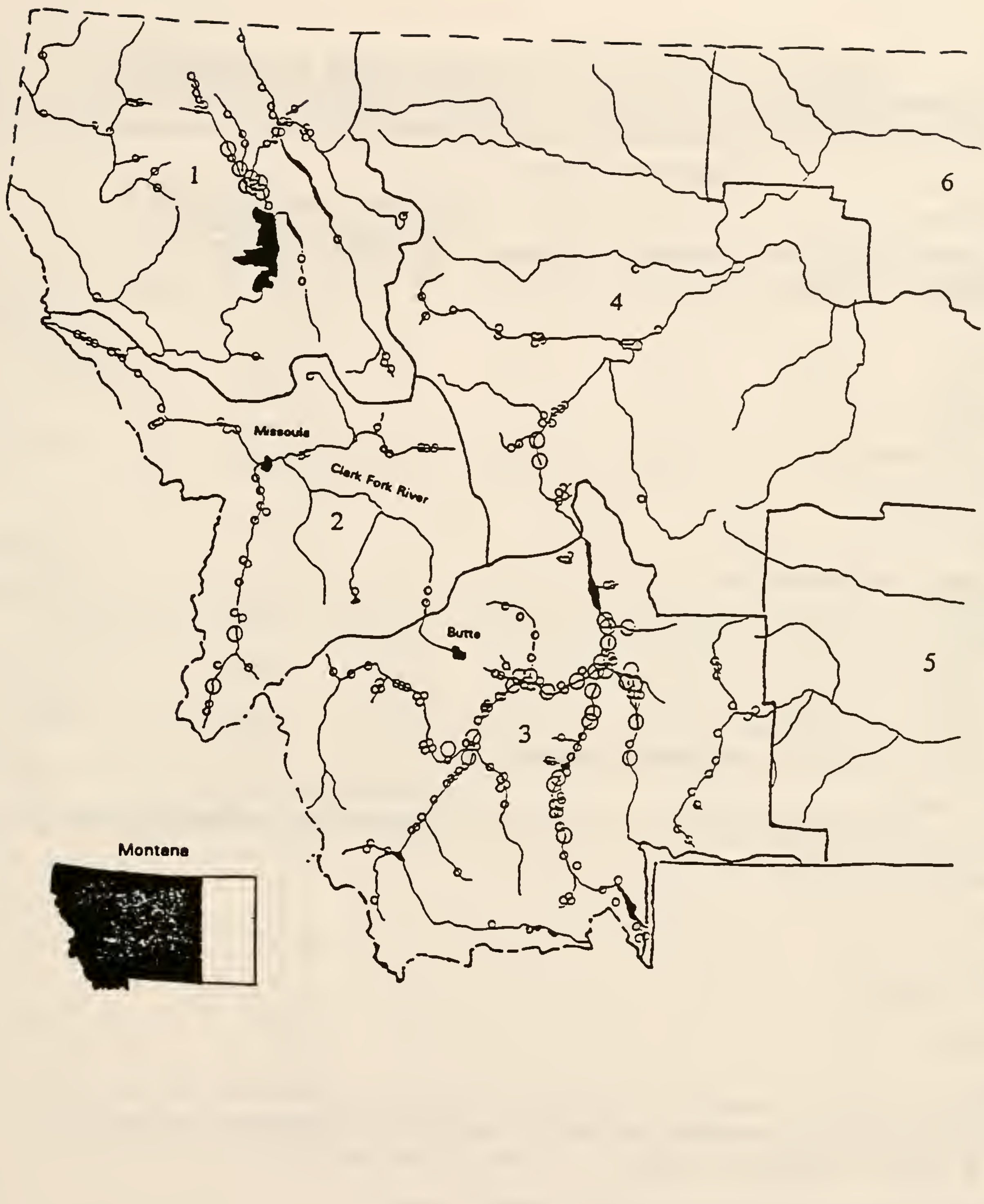

Figure 7. Map of western Montana showing the numbers and locations of otter trapped in each Montana Department of Fish, Wildlife, and Parks administrative region (numbers) during the 1977-78 through 1989-90 trapping season. (Adapted from Zackheim 1982); small circles indicate single otter, large circles indicate five otter. Note that only two otters were trapped on the upper Clark Fork River during this time period.

Table 1. Frequency of occurrence of food items in intestine and stomach of mink collected from all Clark Fork River and reference sites during 1991-1992 trapping season.

Intestine Samples (N = 26)[a]

Food Item	Percent Frequency of Occurrence in Samples
Unidentified Fish	30.8
Sucker	15.4
Trout	11.5
Whitefish	3.8
Overall Fish	61.5[b]
Small Rodent	11.5
Muskrat	7.7
Aquatic Invertebrates	26.9
Empty	26.9

Stomach Samples (N = 26)[a]

Food Item	Percent Frequency of Occurrence in Samples
Unidentified Fish	7.7
Trout	3.8
Overall Fish	11.5[c]
Small Rodent	3.8
Muskrat	3.8
Empty	80.8

[a] Intestinal and stomach contents were not determined in one of the 27 mink trapped; thus N = 26 for this analysis.

[b] 84 percent of intestines with food present

[c] 60 percent of stomachs with food present

Table 2. Whitefish mean body weight and mean whole body metal concentrations (and standard Errors of the Means) for fish collected from the Clark Fork River and reference sites in 1991 and 1992.

Year Location	N	Mean (SEM)					
		Fish Wt (g)	Cadmium ng/g dw	Lead ng/g dw	Copper ug/g dw	Zinc ug/g dw	Arsenic ng/g dw
<u>1991</u>							
Warm Springs	4	316 (67)	87[a] (27)	203[a] (49)	4.0 (0.2)	64.6 (1.0)	930[a] (137)
Reference Sites	5	313 (23)	34 (10)	64 (10)	3.2 (0.6)	88.3 (9.3)	546 (110)
<u>1992</u>							
Warm Springs	4	270 (37)	234[a] (24)	468[a] (90)	6.1[a] (0.6)	66.1 (3.6)	386 (40)
Turah Bridge	4	324 (23)	183[a] (37)	558[a] (251)	8.0[a] (1.8)	71.5 (3.9)	338 (193)
Reference Sites	7	296 (28)	43 (7)	106 (23)	3.0 (0.1)	75.7 (4.1)	537 (111)

[a] Significantly higher than control at $\alpha = 0.05$ (see Appendix 5).

Table 3. Sucker mean body weight and mean whole body metal concentrations (and Standard Errors of the Means) for fish collected from the Clark Fork River and reference sites in 1992.

Year, Location	N	Mean (SEM) Fish Wt (g)	Cadmium ng/g dw	Lead ng/g dw	Copper ug/g dw	Zinc ug/g dw	Arsenic ng/g dw
<u>1991</u>		Inadequate number of fish for statistical comparisons					
<u>1992</u>							
Warm Springs	5	883 (61)	345[a] (42)	357[a] (46)	8.2[a] (0.7)	65.8 (4.8)	584 (82)
Turah Bridge	4	588 (66)	166[a] (10)	408[a] (77)	10.6[a] (0.8)	77.5 (3.9)	277 (53)
Reference Sites	4	607 (112)	72 (28)	172 (84)	4.5 (0.1)	72.6 (1.6)	1807 (1252)

[a] Significantly higher than control at $\alpha = 0.05$ (see Appendix 5).

Table 4. Mink mean (and Standard Error of the Mean) liver metal concentrations by trapping location for mink collected on the Clark Fork River and reference sites during the 1991-92 trapping season.

Location	N	Mean (SEM) Cadmium ng/g dw	Lead ng/g dw	Copper ug/g dw	Zinc ug/g dw	Arsenic ng/g dw
<u>Juveniles</u>						
Warm Springs Ponds	3	676 (379)	506[a] (80)	54[a] (12)	117[a] (12)	221[a] (91)
Deer Lodge[b]	2	646 (326)	1093 (237)	56 (15)	111 (16)	308 (137)
Clinton	5	359 (37)	600[a] (63)	43[a] (2)	88 (3)	406[a] (137)
Combined CFR Sites	10	512 (122)	670[a] (88)	49[a] (4)	101 (6)	331[a] (76)
Combined Reference	5	275 (68)	212 (74)	28 (3)	89 (9)	24 (29)
<u>Adults</u>						
Warm Springs Ponds	5	1014[a] (187)	994[a] (132)	35[a] (4)	103[a] (6)	1092 (846)
Deer Lodge[b]	1	1394	826	47	72	189
Clinton	0	NO ADULT MINK CAPTURED				
Combined CFR Sites	6	1078[a] (166)	966[a] (112)	37[a] (4)	98 (7)	942 (706)
Combined Reference	6	434 (78)	187 (104)	19 (2)	85 (5)	269 (178)

[a] Significantly higher than control at $\alpha = 0.05$ (see Appendix 6).

[b] No statistical comparison made due to small sample size.

Table 5. Mink mean (and Standard Error of the Mean) kidney metal concentrations by trapping location for mink collected on the Clark Fork River and reference sites during the 1991-92 trapping season.

		Mean (SEM)				
Location	N	Cadmium ng/g dw	Lead ng/g dw	Copper ug/g dw	Zinc ug/g dw	Arsenic ng/g dw
Juveniles						
Warm Springs Ponds	3	1735 (1040)	463[a] (45)	23[a] (2)	86 (10)	341 (91)
Deer Lodge[b]	2	875 (357)	944 (111)	24 (1)	89 (10)	1263 (886)
Clinton	5	605 (145)	613[a] (70)	18 (1)	75 (3)	196 (63)
Combined CFR Sites	10	998 (326)	634[a] (68)	21 (1)	81 (4)	453 (194)
Combined Reference	5	566 (131)	252 (83)	17 (1)	92 (13)	274 (168)
Adults						
Warm Springs Ponds	5	2604[a] (718)	756[a] (105)	18 (2)	78 (4)	1122 (792)
Deer Lodge[b]	1	3491	996	19	73	413
Clinton	0	NO ADULT MINK CAPTURED				
Combined CFR Sites	6	2752[a] (604)	796[a] (95)	18 (1)	78 (3)	1004 (657)
Combined Reference	6	1114 (326)	211 (113)	15 (1)	69 (3)	180 (107)

[a] Significantly higher than control at $\alpha = 0.05$ (see Appendix 7).

[b] No statistical comparison made due to small sample size.

Table 6. Mink mean (and Standard Error of the Mean) brain metal concentrations by trapping location for mink collected on the Clark Fork River and reference sites during the 1991-92 trapping season.

Location	N	Cadmium ng/g dw	Lead ng/g dw	Copper ug/g dw	Zinc ug/g dw	Arsenic ng/g dw
		Mean (SEM)				
Juveniles						
Warm Springs Ponds	3	194 (118)	111 (96)	20[a] (1)	67 (10)	267[c] (161)
Deer Lodge[b]	2	18 (22)	268 (126)	15 (2)	58 (0)	145 (31)
Clinton	5	1 (3)	28 (24)	15 (1)	50 (2)	164 (31)
Combined CFR Sites	10	62 (42)	28 (45)	16 (1)	57[a] (4)	183 (36)
Combined Reference	5	4 (5)	19 (13)	14 (1)	48 (2)	118 (58)
Adults						
Warm Springs Ponds	5	7 (3)	159[a] (26)	12 (1)	46 (2)	589 (316)
Deer Lodge[b]	1	8	350	10	47	124
Clinton	0	NO ADULT MINK CAPTURED				
Combined CFR Sites	6	7 (3)	191[a] (38)	11 (1)	47 (1)	511 (270)
Combined Reference	6	41 (19)	58 (20)	10 (0)	45 (4)	138 (44)

[a] Significantly higher than control at $\alpha = 0.05$ (see Appendix 8).

[b] No statistical comparison made due to small sample size.

[c] N = 2

Table 7. Comparisons of Fall 1992 furbearer sign (sign/km) on paired Clark Fork/reference sites including P values.

Paired Site	Otter Sign/km	Mink Sign/km	Raccoon Sign/km	Beaver Sign/km
CFR1	0.00	0.22	0.00	6.80
REF1	0.00	2.53	0.51	2.53
CFR2	0.00	0.81	0.12	9.60
REF2	0.13	3.06	1.53	1.28
CFR3	0.00	0.72	0.60	3.47
REF3	0.15	6.82	3.08	2.78
CFR4	0.00	0.45	0.45	6.18
REF4	0.54	2.72	3.26	13.04
CFR5	0.00	0.11	1.56	2.46
REF5	0.00	0.30	3.57	4.02
CFR6	0.00	1.49	0.93	3.07
REF6	1.91	0.24	3.34	5.37
P value	<0.01*	<0.01*	<0.01*	>0.10

* significant at $\alpha = 0.05$; P values determined by a one-sided bootstrap confidence limit test of the species' sign for the six paired sites.

Table 8. Relative proportions of each habitat classification type on paired Clark Fork/reference sites including P values (% of sums further from zero than observed) of a one sample, randomized test of each habitat type on the six paired sites. None of the statistical comparisons were significant at $\alpha = 0.05$. See Appendix 1 for habitat classification descriptions.

	HABITAT CLASSIFICATION											
Site	1	2	3	4	5	6	7	8	9	10	11	12
CFR1	0.240	0.740	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
REF1	0.464	0.107	0.000	0.000	0.429	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CFR2	0.500	0.198	0.000	0.012	0.267	0.000	0.000	0.023	0.000	0.000	0.000	0.000
REF2	0.470	0.197	0.000	0.015	0.273	0.015	0.000	0.000	0.000	0.030	0.000	0.000
CFR3	0.155	0.190	0.000	0.000	0.083	0.000	0.012	0.024	0.060	0.286	0.179	0.012
REF3	0.156	0.178	0.000	0.056	0.122	0.011	0.000	0.178	0.111	0.167	0.000	0.022
CFR4	0.250	0.125	0.000	0.018	0.143	0.000	0.000	0.446	0.000	0.018	0.000	0.000
REF4	0.060	0.120	0.000	0.000	0.000	0.040	0.000	0.760	0.000	0.020	0.000	0.000
CFR5	0.128	0.105	0.000	0.081	0.140	0.000	0.000	0.093	0.093	0.244	0.093	0.023
REF5	0.185	0.176	0.008	0.336	0.076	0.034	0.017	0.008	0.000	0.160	0.000	0.000
CFR6	0.010	0.061	0.000	0.112	0.031	0.000	0.000	0.000	0.153	0.398	0.000	0.235
REF6	0.015	0.074	0.000	0.250	0.044	0.059	0.000	0.000	0.000	0.559	0.000	0.000
P value	0.656	0.656	1.000	0.188	0.781	0.062	1.000	0.500	0.500	1.000	0.500	0.500

Table 9. Mean bank height, median bank height, and mean distance to cover of paired Clark Fork/reference sites, including standard errors of the means and P values (percentage of sums further from zero than observed) of a one sample, randomized test of the six paired sites.

Site	Mean Bank Ht. (m) (SEM)	Median Bank Ht. (m) (SEM)	Mean Distance to Cover (m) (SEM)
CFR1	0.8490 (0.1041)	1.0000 (0.1041)	0.9300 (0.2000)
REF1	0.4880 (0.0575)	0.5000 (0.0575)	3.7547 (0.2824)
CFR2	0.7267 (0.0722)	0.7500 (0.0722)	3.2035 (0.2091)
REF2	0.0588 (0.0223)	0.0000 (0.0223)	3.6618 (0.2016)
CFR3	0.7256 (0.1226)	0.5000 (0.1226)	2.0893 (0.2109)
REF3	0.1556 (0.0423)	0.0000 (0.0423)	2.6444 (0.1887)
CFR4	1.1295 (0.1562)	1.0000 (0.1562)	1.3571 (0.2123)
REF4	0.5426 (0.1298)	0.2500 (0.1298)	1.8800 (0.2293)
CFR5	0.3256 (0.0666)	0.0000 (0.0666)	2.6686 (0.2347)
REF5	1.2250 (0.0811)	1.0000 (0.0811)	1.5667 (0.1255)
CFR6	0.5365 (0.1109)	0.0000 (0.1109)	1.9427 (0.1791)
REF6	0.3571 (0.0961)	0.0000 (0.0961)	2.0071 (0.2140)
P value	0.3438	0.4375	0.4375

Table 10. Relative proportions of the nearest cover type on paired Clark Fork/reference sites including P values (% of sums further from zero than observed) of a one sample, randomized test of each cover type on the six paired sites. None of the statistical comparisons were significant at $\alpha = 0.05$. See Appendix 2 for cover type descriptions. Note that the proportions do not sum to 1.0 for many sites since some sites had a proportion with "no cover".

	COVER TYPE											
Site	1	2	3	4	5	6	7	8	9	10	11	12
CFR1	0.080	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
REF1	0.472	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CFR2	0.791	0.174	0.000	0.000	0.023	0.012	0.000	0.000	0.000	0.000	0.000	0.000
REF2	0.559	0.353	0.044	0.015	0.000	0.015	0.015	0.000	0.000	0.000	0.000	0.000
CFR3	0.405	0.417	0.060	0.012	0.012	0.012	0.000	0.012	0.012	0.012	0.048	0.000
REF3	0.433	0.356	0.067	0.000	0.000	0.000	0.000	0.011	0.133	0.000	0.000	0.000
CFR4	0.304	0.411	0.000	0.000	0.000	0.000	0.000	0.000	0.268	0.000	0.018	0.000
REF4	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.600	0.000	0.000	0.000
CFR5	0.546	0.209	0.012	0.000	0.000	0.046	0.000	0.000	0.023	0.000	0.151	0.012
REF5	0.367	0.275	0.017	0.000	0.208	0.000	0.000	0.000	0.042	0.000	0.008	0.083
CFR6	0.344	0.479	0.052	0.021	0.000	0.000	0.000	0.021	0.010	0.000	0.073	0.000
REF6	0.471	0.414	0.057	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.000
P value	0.188	0.625	0.125	0.750	1.000	0.500	1.000	0.500	0.250	1.000	0.125	1.000

Table 11. Total number of otter trapped on the Clark Fork, Big Hole, and Bitterroot rivers from 1981 - 1990 including otter trapped per river mile. See Table 12 for statistical comparisons.

Trapping Year	Clark Fork[a]		Big Hole[b]		Bitterroot[c]	
	No.	No./mile	No.	No./mile	No.	No./mile
1980 - 81	0	0.0000	1	0.0072	2	0.0173
1981 - 82	0	0.0000	1	0.0072	0	0.0000
1982 - 83	0	0.0000	1	0.0072	0	0.0000
1983 - 84	0	0.0000	1	0.0072	2	0.0173
1984 - 85	0	0.0000	6	0.0431	2	0.0173
1985 - 86	Insufficiently Detailed Information					
1986 - 87	1	0.0082	1	0.0072	6	0.0520
1987 - 88	0	0.0000	2	0.0144	6	0.0520
1988 - 89	1	0.0082	0	0.0000	3	0.0260
1989 - 90	0	0.0000	0	0.0000	3	0.0260

[a] Clark Fork River - Warm Springs Ponds to Milltown Reservoir (122.0 river miles)

[b] Big Hole River - Jackson to confluence with Jefferson River (139.2 river miles)

[c] Bitterroot River - Headwaters of West Fork of Bitterroot to confluence with Clark Fork (115.4 river miles)

Table 12. P values of statistical comparison of otter trapped per river mile (1981 - 1990) between the Clark Fork and Big Hole rivers, the Clark Fork and Bitterroot rivers, and the Bitterroot and Big Hole rivers.

Comparison	P value
*CFR V BHR	0.0469 (% of sums $\geq$ observed)
*CFR V BRR	0.0078 (% of sums $\geq$ observed)
BRR V BHR	0.1289 (% of sums further from zero)

* significant at $\alpha = 0.05$

Table 13. Beaver trapped per unit area (Region 2 vs. Region 3) from 1985 - 1989, including P values for beaver (percentage of sums $\geq$ observed) from a one sample randomized test of paired year data of beaver trapped per unit area.

Beaver Trapped (Region 2 V Region 3)				
	Region 2		Region 3	
Year	Beaver	Beaver/UA[a]	Beaver	Beaver/UA[b]
1985	571	0.0327	1575	0.0590
1986	569	0.0326	1166	0.0436
1987	908	0.0520	761	0.0285
1988	553	0.0316	668	0.0250
1989	541	0.0310	752	0.0281

P value = 0.4688

[a] Region 2 unit area based on planimetry = 17,471

[b] Region 3 unit area based on planimetry = 26,716

Table 14. Tissue Residue Criteria (TRC) for Pb and Cd in the diet of mink and otter, calculated using a model developed by Newell et al. (1987), LOAEL values from the published literature, and uncertainty factors, as described in the text.

	Toxicity Data				Uncertainty Factors[a]			Tissue Residue Criteria (ug/kg diet)	
Chemical	Test Species	Endpoint	LOAEL (ug/kg/d)	Reference	UF_E	UF_S	UF_C	Mink	Otter
Lead	Monkey	Behavior	100	Rice, 1985	10	1	1	67	89
Cadmium	Rats	Birth Defects	6000	Ferm & Layton 1981	10	1	10	400	533

[a] Uncertainty factors defined in text

Table 15. Tissue Residue Criteria (TRC) values and dietary exposure concentrations for Cd and Pb for mink and otter consuming fish collected from below Warm Springs Ponds and reference sites, based on mink consuming a diet of either 50 or 100 percent trophic level 3 fish (sucker), and otter consuming a diet of 50 percent trophic level 3 (sucker) and 50 percent trophic level 4 fish (brown trout).

Species (Trophic Level)[b]	Cadmium			Lead		
	Tissue Residue Criteria (ug/kg diet)	Dietary Exposure Concentration (ug/kg diet)[a]		Tissue Residue Criteria (ug/kg diet)	Dietary Exposure Concentration (ug/kg diet)[a]	
		Warm Springs	Reference Site		Warm Springs	Reference Site
Mink 50% Trophic Level 3 Fish	400	49	10	67	51	25
Mink 100% Trophic Level 3 Fish	400	99	21	67	102	49
Otter 50% Trophic Level 3 and 50% Trophic Level 4 Fish	533	70	36	89	157	76

[a]Dietary exposure presented as ug metal/kg expressed as wet weight, calculated from dry weight metal concentrations for suckers (trophic level 3 fish) presented in Table 3 and from dry weight concentrations for brown trout (trophic level 4 fish) presented by Bergman (1993).

[b]Based on dietary composition of trophic level 3 and 4 fish in mink and otter as specified by USEPA (1993), as discussed in the text.

Appendix 1. Description of habitat classifications used in paired Clark Fork and Big Hole reference site comparisons.

Habitat Classification Number	Habitat Description
1	Low density shrub (non-continuous stream side coverage of shrubs)
2	High density shrub (continuous stream side coverage of shrubs)
3	Dead shrub stand
4	Deciduous tree dominated overstory (no understory)
5	Grassland
6	Upland scrub (sage brush dominated)
7	Boulder
8	Riprap
9	Conifer dominated overstory (steep-banked, with little or no understory)
10	Mixed overstory (deciduous and conifer with shrub understory)
11	Cobble bar
12	Mixed overstory (deciduous and conifer with no understory)

Appendix 2. Description of cover classifications used in paired Clark Fork and Big Hole reference site comparisons.

Cover Classification Number	Cover Description
1	Shrub
2	Grass
3	Tree
4	Log jam
5	Bank overhang
6	Dead tree snag
7	Dead willow
8	Root ball
9	Boulder
10	Conifer
11	Log
12	Bank den

Appendix 3. Sample Necropsy Record showing trapping information, tissue examined, and tissues taken for histology and metal concentration analysis.

ID#	Trapper's Name
Species/Sex	Date Trapped
Length (cm)	Trap Location
Weight (kg)	

Necropsy Record	Samples Collected	
(check off/comments)		
External	Histology	Metal Analysis
Teeth	(check off)	(vial#)
Tongue	Tongue	
Esophagus		
Trachea/Bronchi		
Lung	Lung	
Heart/Valves	Heart	Blood
Liver	Liver	Liver
Gall Bladder	Gall Bladder	Bile
Kidney	Kidney	Kidney
Spleen	Spleen	
Pancreas	Pancreas	
Stomach	Stomach	Contents
Intestine	Intestine	
Body Condition	Mes. Lymph Node	
Brain	Brain	Brain
Productivity	Fetus	Fetus
Additional Comments	Placenta	Placenta
	Uterus	Uterus
	Testis	Testis
	Ovary	Ovary
	Urinary Bladder	Fur
	Skel. Muscle	Femur
	Baculum (aging)	

Appendix 4. Mink trapping results from the Clark Fork River and reference sites, 1991 - 1992 trapping season.

Mink I.D.	Sex (M/F)	Age (J/A)	Trap Location
Clark Fork River			
131	F	J	Silver Bow Creek near Warm Springs Ponds
142	M	J	Clark Fork River near Warm Springs Ponds
144	M	J	Clark Fork River near Warm Springs Ponds
137	M	A	Clark Fork River near Warm Springs Ponds
143	M	A	Clark Fork River near Warm Springs Ponds
145	M	A	Clark Fork River near Warm Springs Ponds
194	M	A	Clark Fork River near Warm Springs Ponds
195	M	A	Clark Fork River near Warm Springs Ponds
155	F	J	Clark Fork River near Deer Lodge
193	M	J	Clark Fork River near Deer Lodge
182	M	A	Clark Fork River near Deer Lodge
148	F	J	Clark Fork River near Clinton
149	F	J	Clark Fork River near Clinton
150	F	J	Clark Fork River near Clinton
153	F	J	Clark Fork River near Clinton
154	F	J	Clark Fork River near Clinton
Reference Sites			
140	F	J	Rock Creek near Clark Fork
146	M	J	Upper Rock Creek
147	M	J	Upper Rock Creek
151	M	J	Upper Rock Creek
184	M	J	Rock Creek near Clark Fork
133	M	A	Big Hole River near Sawlog Creek
134	M	A	Big Hole River near Fishtrap Creek
135	M	A	Big Hole River near Sawlog Creek
141	M	A	Foster Creek
152	M	A	Upper Rock Creek
183	M	A	Rock Creek near Clark Fork

Appendix 5. Statistical comparison of fish tissue metal concentrations including P values of mean difference ($\leq$ observed) and F ratio (largest variance/smallest variance $\geq$ observed) of a two sample randomized test. See Tables 2 and 3 for metal concentration values.

Year, Species, Site Comparison	P values Mean Difference (F ratio)				
	Cadmium	Lead	Copper	Zinc	Arsenic
1991					
Whitefish WSP V REF	*0.0285 (0.6712)	*0.0064 (0.0709)	0.1377 (0.0781)	0.9691 (0.0070)	*0.0362 (0.8174)
1992					
Whitefish WSP V REF	*0.0037 (0.1083)	*0.0027 (0.0955)	*0.0028 (0.1077)	0.9469 (0.8319)	0.8254 (0.0196)
Whitefish TB V REF	*0.0038 (0.1099)	*0.0025 (0.0526)	*0.0010 (0.0560)	0.7305 (0.8562)	0.8205 (0.4947)
Sucker WSP V REF	*0.0070 (0.2100)	*0.0406 (0.3007)	*0.0071 (0.0031)	0.8379 (0.2996)	0.7756 (0.0740)
Sucker TB V REF	*0.0146 (0.1644)	*0.0407 (0.7894)	*0.0134 (0.0229)	0.1516 (0.1535)	0.9015 (0.2546)

* significant at $\alpha = 0.05$

Appendix 6. Statistical comparison of mink liver metal concentrations, including P values of mean difference ($\leq$ observed) and F ratio (largest variance /smallest variance $\geq$ observed) of a two sample randomized test. See Table 4 for metal concentration values.

Age/Site Comparison	P values Mean Difference (F ratio)				
	Cadmium	Lead	Copper	Zinc	Arsenic
Adult WSP V REF	*0.0076 (0.1822)	*0.0036 (0.9042)	*0.0034 (0.4694)	*0.0225 (0.8155)	0.2414 (0.8927)
Juvenile WSP V REF	0.1448 (0.6376)	*0.0372 (0.6252)	*0.0179 (0.3927)	*0.0347 (0.9962)	*0.0342 (0.3223)
Juvenile CLN V REF	0.1683 (0.1866)	*0.0044 (0.8217)	*0.0052 (0.2765)	0.5276 (0.3802)	*0.0231 (0.0165)
Adult CFR V REF	*0.0053 (0.0957)	*0.0031 (0.9437)	*0.0022 (0.2319)	0.0760 (0.5571)	0.2838 (0.9997)
Juvenile CFR V REF	0.0654 (0.5056)	*0.0006 (0.4645)	*0.0006 (0.2627)	0.1248 (0.9319)	*0.0029 (0.0042)

* significant at $\alpha = 0.05$

Appendix 7. Statistical comparison of mink kidney metal concentrations including P values of mean difference ($\leq$ observed) and F ratio (largest variance /smallest variance $\geq$ observed) of a two sample randomized test. See Table 5 for metal concentration values.

Age/Site Comparison	P values Mean Difference (F ratio)				
	Cadmium	Lead	Copper	Zinc	Arsenic
Adult WSP V REF	*0.0428 (0.1259)	*0.0096 (0.5920)	0.1235 (0.2123)	0.0579 (0.8895)	0.0690 (0.7090)
Juvenile WSP V REF	0.1437 (0.6834)	*0.0347 (0.2876)	*0.0191 (0.7487)	0.6062 (0.2849)	0.3914 (0.6410)
Juvenile CLN V REF	0.4267 (0.8303)	*0.0082 (0.8522)	0.4104 (0.9244)	0.8447 (0.0212)	0.5692 (0.8362)
Adult CFR V REF	*0.0226 (0.0804)	*0.0042 (0.4389)	0.0795 (0.2080)	0.0611 (0.9845)	0.0593 (0.8947)
Juvenile CFR V REF	0.1671 (0.6990)	*0.0016 (0.6839)	0.0649 (0.3776)	0.8528 (0.0811)	0.3738 (0.9750)

* significant at $\alpha = 0.05$

Appendix 8. Statistical comparison of mink brain metal concentrations including P values of mean difference ($\leq$ observed) and F ratio (largest variance /smallest variance $\geq$ observed) of a two sample randomized test. See Table 6 for metal concentration values.

Age/Site Comparison	P values Mean Difference (F ratio)				
	Cadmium	Lead	Copper	Zinc	Arsenic
Adult WSP V REF	0.9500 (0.0730)	*0.0084 (0.6700)	0.0733 (0.1288)	0.3629 (0.0472)	0.0518 (0.0784)
Juvenile WSP V REF	0.0517 (0.2579)	0.1834 (0.0856)	*0.0197 (0.0719)	0.0548 (0.2760)	0.2043 (0.6715)
Juvenile CLN V REF	0.6876 (0.8155)	0.3880 (0.1781)	0.2501 (0.1855)	0.2270 (0.3365)	0.2423 (0.1992)
Adult CFR V REF	0.9592 (0.0485)	*0.0050 (0.2618)	0.0939 (0.1768)	0.3470 (0.0279)	0.0780 (0.1453)
Juvenile CFR V REF	0.1977 (0.2802)	0.1147 (0.0115)	0.0608 (0.8918)	*0.0361 (0.1366)	0.1744 (0.9434)

* significant at $\alpha = 0.05$